DISSIPATION AND LEACHING OF $^{14}$C-MONOCROTOPHOS IN SOIL COLUMNS

KOMAL VIG, DILEEP K. SINGH, H.C. AGARWAL
Department of Zoology
University of Delhi, Delhi, India.

Abstract

Dissipation and leaching of $^{14}$C-monocrotophos was studied in the field. Two sets of PVC cylinders were used-one set received only $^{14}$C-monocrotophos and the other received $^{14}$C-monocrotophos along with dimethoate, deltamethrin, endosulfan, cypermethrin and triazophos at intervals of 15 days each. Each column received 37 kBq of $^{14}$C-monocrotophos and 1.06 mg unlabelled monocrotophos. Both setups showed a similar pattern of dissipation with an half-life of 277.2 days. Leaching of monocrotophos was observed into the 30cm soil layer.

1. INTRODUCTION

Most of the insecticide residues present in soil originate from deliberate applications to the soil or to the foliage of crop plants and weeds, where considerable quantities reach the soil either by missing the “target” or by run-off from leaves and stems [1,2]. A proportion of the insecticides applied, eventually become incorporated into the soil. Dispersion of pesticides and their transformation products within the soil environment, or from the soil to other environments, is influenced not only by the properties of the pesticides and the soil but also the prevailing climatic conditions. Soil properties known to influence the persistence of pesticides in tropical areas include soil moisture [3] organic matter content [4,5,6], redox status [7], soil pH [8], temperature [9], sorption-desorption [10], and mineral constituents [11]. Significant interactions between pesticides applied in combination, in terms of their persistence in soils and toxicity to crops and insects, have been demonstrated [12,13]. The combinations of various pesticides may result in interactions that show additive, synergistic or antagonistic effects and may deviate from the behaviour of the individual components [14].

Leaching is an important means of dispersion of pesticides in soil. The extent of leaching is determined by the solubility, adsorptive properties and rate of degradation of the pesticide, as well as by the natural water movement in soil, and the physical and chemical characteristics of the soil. Soil organic matter content is generally inversely correlated with pesticide mobility in soil. Leaching of certain pesticides has been studied extensively by many workers [15,16,17]. A direct correlation between adsorption and soil organic matter content has been observed [18]. In the present study dissipation and leaching of $^{14}$C-monocrotophos was studied individually and in combination with insecticides recommended for the cotton crop.

2. MATERIALS AND METHODS

2.1. Insecticides

The insecticides used were typical of those associated with cultivation of cotton and were purchased locally. Their common and IUPAC names are given below:

(i) Dimethoate; $O,O$-dimethyl $S$-methylcarbamoylmethyl phosphorodithioate
(ii) Monocrotophos; Dimethyl ($E$)-1-methyl-2-(methylcarbamoyl)vinyl phosphate
(iii) Deltamethrin; (S)-$\alpha$-cyano-3-phenoxybenzyl($1R$)-cis-3-(2,2-dibromovinyl)-2,2-dimethyl-cyclopropanecarboxylate
(iv) Endosulfan; (1,4,5,6,7-hexachloro-8,9,10-trinorborn-5-en-2,3-ylenebismethylene) sulphite
(v) Cypermethrin; ($RS$)-$\alpha$-cyano-3-phenoxybenzyl ($1RS$)-cis-trans-3-(2,2-dichlorovinyl)-1,1-dimethyl-cyclopropanecarboxylate
(vi) Triazophos; 0,0-diethyl 0-1-phenyl-1H-1,2,4-triazol-3-yl phosphorothioate
2.2. Physical and chemical analysis of soil

Analyses were done taking appropriate samples of soil using standard techniques. Soil pH was measured using saturated soil solution (1:2.5 soil:water). Conductivity was also measured using saturated soil solution (1:2.5 soil:water). Organic carbon was estimated by the modified Walkley-Black method [19]. Plant available phosphorus was estimated by Olsen’s method [20].

2.3. Soil column experiment with $^{14}$C-monocrotophos

2.3.1. Layout

Polyvinyl chloride cylinders (40 cm long & 5 cm i.d.) open at both ends were used for this experiment. Cylinders were inserted in the soil in the field at the campus of University of Delhi, Delhi, India (lat. 29°N, long. 77.3°E), two weeks prior to application, with about 3 cm of the cylinder projecting above the soil surface to prevent the flow of run-off water. Two sets of PVC cylinders were used, with clean soil (with no previous insecticide history), and no plants. The first set (24 cylinders) were treated only with $^{14}$C- labelled monocrotophos. The second set (24 cylinders) received $^{14}$C- labelled monocrotophos plus other non-labelled insecticides. Concentrations, time and frequency of application (including the radiochemical) are given in Table 1. The first treatment was with dimethoate followed by monocrotophos ($^{14}$C and unlabelled monocrotophos) and others as shown in Table 1. The cylinders were left until removed for sampling.

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Dosage (g a.i/ha)</th>
<th>Time of spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethoate (Rogor 30 EC)</td>
<td>300</td>
<td>0 day</td>
</tr>
<tr>
<td>Monochrotophos (Nuvacron 36 SL)*</td>
<td>500</td>
<td>15 days after first treatment</td>
</tr>
<tr>
<td>Deltamethrin (Decis 2.8 EC)</td>
<td>12.5</td>
<td>30 days after first treatment</td>
</tr>
<tr>
<td>Endosulfan (Thiodon 35 EC)</td>
<td>750</td>
<td>45 days after first treatment</td>
</tr>
<tr>
<td>Cypermethrin (Cypermethrin 10 EC)</td>
<td>60</td>
<td>60 days after first treatment</td>
</tr>
<tr>
<td>Trizophos (Hostathon 40 EC)</td>
<td>600</td>
<td>75 days after first treatment</td>
</tr>
</tbody>
</table>

*37 kBq $^{14}$C-monocrotophos + 1.06 mg unlabelled monocrotophos was added

2.3.2. $^{14}$C-Monocrotophos

The monocrotophos was ring labelled at both methyl groups; specific activity 969.4 MBq/mol; purity by TLC 98%. Thirty seven kBq in acetone were diluted with 1.06 mg unlabelled monocrotophos and applied to each cylinder. The amount used was equivalent to a concentration of 2 mg/kg in the top 15 cm of the soil.

2.3.3. Sampling

Samples were taken in triplicate 0, 90, 180, 270 and 365 days after treatment with monocrotophos. Cylinders were removed for analysis at random. The soil columns were sliced into 0-15 cm and 15-30 cm sections for analysis. The soil was air-dried, ground and mixed thoroughly and three sub-samples (from each depth) were analyzed from each cylinder. Soil was stored at -20°C till analyzed.

2.3.4. Extraction and analyses

Total residues were estimated in all samples using 300 mg aliquots in triplicate by combustion in a Harvey Biological Oxidizer (Model OX-400). Efficiency of the estimation was about 80%. A Packard 2000 CA liquid scintillation spectrometer with automatic quench correction facility was used for these estimations.
3. RESULTS AND DISCUSSION

The soil used was a sandy loam (sand 59.3%, silt 25.9%, clay 14.8%) with pH 7.9, conductivity 152.3 µSiemens, organic carbon 0.35% and available P 1.56 kg/ha. In soil columns which received only 14C-monocrotophos, 1.892 µg/g d.wt. soil was present on day zero of which only 54.88% remained 90 days after the treatment in the 0-15 cm soil layer whereas in columns treated with 14C-monocrotophos along with other insecticides 1.304 µg/g d.wt. soil were present on zero day of which 74.76% remained 90 days after the treatment (Table 2). After 180 days 46% and 45.7% of the residues could be detected in both types of columns and after 365 days similar residues remained (38.32 and 39.57% of initial) in both (Tables 2,3). Total half-life calculated from 0-15 cm soil was 277.2 days for both soils. Leaching of 14C-monocrotophos was observed in both experimental plots (Tables 2,3). Total residues detected in 15-30 cm soil on zero day were 0.133 and 0.155 µg/g d.wt. soil in soil columns treated with only 14C-monocrotophos and in the columns which received 14C-monocrotophos along with other insecticides respectively, which amount to 7.05 and 11.85% of the residues present in the 0-15 cm soil at that time (Tables 2,3).

Residues present in the 15-30 cm layer of the soil increased gradually to 0.25 µg/g d.wt. soil 180 days after treatment in the columns which received 14C-monocrotophos along with other insecticides (Table 3), however, not much change in the total residues was observed from zero to 365 days. After 365 days 22.67 and 22.22% of the residues had leached to 30 cm soil. In the present experiment leaching of monocrotophos was observed into the 30cm soil layer [cf.18]. The extent of leaching is determined by the solubility, adsorptive properties and rate of degradation of the pesticide, as well as by the natural water movement in, and the physical and chemical characteristics of the soil and is generally inversely correlated with soil organic matter content [21]. The half-life of monocrotophos reported in the literature is reasonably short [18,22,23]. However, our data show that monocrotophos persists in the soil for a much longer time. This may be due in part to the leaching of monocrotophos into the soil which appears to reduce dissipation, and also the formation of bound residues which are known to persist for long periods of time in soil [24]. However, the extent of bound residues could not be estimated.

Table 2. 14C-monocrotophos in soil columns treated only with monocrotophos under field conditions

<table>
<thead>
<tr>
<th>Days after treatment</th>
<th>Total monocrotophos residues (µg/g d.wt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15 cm</td>
</tr>
<tr>
<td>0</td>
<td>1.892±0.59</td>
</tr>
<tr>
<td>90</td>
<td>1.039±0.18</td>
</tr>
<tr>
<td>180</td>
<td>0.871±0.16</td>
</tr>
<tr>
<td>270</td>
<td>0.737±0.16</td>
</tr>
<tr>
<td>365</td>
<td>0.725±0.05</td>
</tr>
</tbody>
</table>

Insecticides treatment schedule as in Table 1.

Table 3. 14C-monocrotophos in soil columns treated only with monocrotophos and other insecticides under field conditions

<table>
<thead>
<tr>
<th>Days after treatment</th>
<th>Total monocrotophos residues (µg/g d.wt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15 cm</td>
</tr>
<tr>
<td>0</td>
<td>1.304±0.46</td>
</tr>
<tr>
<td>90</td>
<td>0.975±0.18</td>
</tr>
<tr>
<td>180</td>
<td>0.597±0.15</td>
</tr>
<tr>
<td>270</td>
<td>0.589±0.15</td>
</tr>
<tr>
<td>365</td>
<td>0.516±0.07</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENT

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REFERENCES


