Occupational exposure of Sri Lankan tea plantation workers to paraquat

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Absorption of the herbicide paraquat (1,1’-dimethyl-4,4’-bipyridinium) by mixer–loaders and spray operators on a Sri Lankan tea plantation was assessed over five consecutive days of spraying. Beginning on the day before spraying started and continuing for each of the five spraying days and for seven days after the last day of spraying, 24-hour urine samples were collected from each of the workers. Potential dermal exposure was assessed during further applications of paraquat on the day after the last day of urine collection. For this purpose two spraying replicates were conducted that involved the handling or spraying of an amount of paraquat equivalent to the maximum used per day in the assessment of absorption.

The mixer–loaders and spray operators incurred, on average, approximately equivalent amounts of potential dermal exposure (66 mg and 74 mg paraquat ion, resp.); however, the distribution of the exposure differed. About 86% of the total exposure experienced by the mixer–loaders was to the hands, whereas about 90% of the exposure of the spray operators involved their hands, legs, and feet, in approximately equal proportions. In both cases, 90% or more of the total potential exposure involved parts of the body that were normally uncovered. Despite the evidence of dermal exposure, no paraquat was detected in the workers’ urine. This probably was due to the very low concentration of paraquat in the solutions used for spot spraying on tea plantations (0.3–0.4 g paraquat ion per litre), the high standard of personal hygiene exercised by the workers, and the low permeability of human skin to paraquat.

Introduction

The study was carried out to assess the dermal exposure to and absorption of paraquat (1,1’-dimethyl-4,4’-bipyridinium) by workers involved in its spray application for the control of weeds on tea plantations in Sri Lanka. The study was conducted in association with an epidemiological investigation of the health of tea plantation workers to determine whether they suffered any long-term effects from using paraquat (7). The study confirmed that long-term spraying of paraquat at the concentrations used produced no adverse effects, in particular no lung damage, attributable to the occupational use of the herbicide.

Similar studies have been conducted previously of workers who used paraquat to control weeds in rubber and oil palm estates in Malaysia (2, 3). Chester & Woollen (3) have described an exposure study in which dermal exposure was measured using the “patch” technique (4). A limited amount of information was also obtained on absorption of paraquat by taking “spot” urine samples. The main objective of the present study was to measure absorption of paraquat accurately by collecting 24-hour urine samples. Dermal exposure was measured using the more accurate “whole body” sampling method.⁵

For rats there is a threshold concentration of paraquat (0.2–0.5 μg/ml in plasma) below which it does not accumulate in the lung, the main target organ for toxicity (5). Rose et al. have shown that human lung behaves similarly to rat lung in terms of its uptake and release of paraquat (6). In the present study we measured the concentration of paraquat in urine, which is always much higher than the corresponding concentration in plasma (7). Furthermore, the kidney is the major route of excretion for paraquat absorbed into the bloodstream. In rats the kidney eliminates more than 80% of absorbed paraquat following subcutaneous injection (8). Determination of the level of paraquat in urine is therefore an appropriate way of measuring accurately its absorption by workers.

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The study was conducted in Sri Lanka on the tea plantations of Janatha Estates Development Board (JEDB), Dickoya, Hatton District, during March 1987.

Materials and methods

Formulation and equipment
Paraquat is available in Sri Lanka as Gramoxone W, an aqueous solution containing 200 g/l of paraquat ion and wetting agents, for the control of weeds on tea plantations. It is applied using hand-operated or pressure-retaining knapsack sprayers. The dilution of Gramoxone used on the JEDB plantations for mature tea is that recommended by the Tea Research Institute (TRI) of Sri Lanka (300–450 ml of product in 225 litres of water), equivalent to a spray solution concentration of 0.27–0.40 g of paraquat per litre; it is recommended for immature tea. A typical rate of 0.7 litres of product in 450 litres of water per ha was used in the general weed control spraying programme in this study, giving a spray solution concentration of 0.31 g/l.

All the spray operators used Kayspray® knapsack sprayers (volume, 15 litres). The nozzles employed were standardized double conejets (nominal flow rate, 1 litre/min).

Workers and study design
A total of 12 workers (2 mixer–loaders and 10 spray operators) were recruited from participants in the associated epidemiological study (1), which consisted of 85 spray operators and mixer–loaders whose health was compared with that of control groups of factory and general workers. The only selection criterion for the workers was that they should have used paraquat for a minimum of 5 years and they were excluded only if they had any illness for which there was evidence that it was not work related. The personal details of the 12 workers (age, height, and weight) were recorded. The mixer–loaders diluted pesticide formulations in large drums and transferred the resultant spray solution to knapsack tanks using buckets; no protective equipment was employed. The spray operators applied the diluted solutions with their own knapsack sprayers and were responsible for cleaning and maintaining this equipment.

The normal work clothing of the mixer–loaders and spray operators was a short-sleeved shirt, shorts, but no socks or footwear. We standardized this cloth-

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contaminating the urine with extraneous paraquat from their hands, the workers were asked to exercise caution when urinating into the container.

On receipt of the 24-hour samples, the volumes of urine were measured and recorded. Two 20-ml aliquots (A and B) were placed in Sterilin vials labelled with the sample sequence number, study number, and date. Sodium azide (Analar) was added to each 20-ml sample of urine at a concentration of approximately 0.1% w/v as a preserving agent. The duplicate sets of samples (A and B) were stored in separate racks in a deep-freeze. At the end of the study the “A” set was air-freighted to ICI Central Toxicology Laboratory, in England, for analysis of paraquat, while the “B” set was kept in the deep-freeze in Sri Lanka as a backup.

After the 13 days of urine collection, the workers made further applications of paraquat during which two replicate measurements of potential dermal exposure were obtained. Each replicate measurement consisted of the application of four knapsack tanks by each worker; this took approximately 1 hour. Thus the quantities of paraquat handled or sprayed per replicate application were standardized for the mixer-loaders and spray operators.

For the measurement of dermal exposure all the workers wore a Tyvek coverall (which included a hood), cotton gloves, and nylon socks. These sampling garments were put on before the start of mixing and loading or spraying and were worn throughout the respective replicate measurements. On completion of the spray application of four knapsack tanks in each replicate, the garments were removed with the assistance of the study supervisors to avoid cross-contamination by the workers; the garments were turned inside out to minimize any loss of paraquat.

The garments from the first replicate were sectioned in the field into upper and lower legs, upper and lower arms, back and front torso, and hood. These sections were then placed individually in appropriately labelled polyethylene bags. The samples were stored at ambient temperature out of direct sunlight until they were air-freighted, under ambient conditions, to ZENECA Agrochemicals, England, for determination of paraquat.

Field recovery of paraquat

The potential losses of paraquat from the sampling garment materials owing to possible degradation and exposure to light were determined on the day the dermal exposure was assessed. For this purpose, 0.1-ml aliquots of a representative sample of spray-dilution of paraquat made up during the assessment of exposure were applied using a microsyringe to ten 25-cm² pieces each of Tyvek, cotton glove, and nylon sock materials (100 µl spray = 0.03 mg paraquat). Half of the samples were exposed to daylight for a period equivalent to the duration of a replicate of exposure measurement to assess any associated losses. These samples were then stored as described above for the dermal exposure samples, as were the remaining samples. The procedure was repeated using 10-µl aliquots of the Gramoxone W formulation (10 µl Gramoxone = 2 mg paraquat).

Five representative samples of knapsack tank mixes, including the one used for field recovery work and a sample of the Gramoxone W formulation, were collected and stored under the same conditions as the exposure samples to confirm, by analysis, the concentration of paraquat. The tank mix samples were labelled with the worker’s number, date, and the number of the tank from which they were taken; the formulation sample was labelled as such together with the date and batch number.

Weather conditions

The temperature in the shade and relative humidity were measured several times each day at the spray application site using a whirling hygrometer. Wind-speed was measured at the same time using a wind-meter.

Analysis

Urine. The level of paraquat in the urine samples was determined by radioimmunoassay (9). The samples were thawed immediately prior to analysis. The lower limit of determination for urine was 0.03 µg paraquat ion per ml. Creatinine was determined using the Jaffé reaction.

Dermal exposure sampling garments. The garments used to determine the dermal exposure were extracted and analysed for paraquat using modified versions of the residue analytical method for food crops. Sections of coveralls, together with the cotton gloves and nylon socks, were shredded individually and each shredded sample was extracted using a saturated solution of ammonium chloride. Immediately prior to spectrophotometric determination of paraquat, 2 ml of a solution of alkaline sodium dithionite was added to each extract (10 ml). Further dilutions of the samples were made if necessary. The levels of

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* From: Dwyer, Instruments, Inc., Michigan City, IN, USA.
paraquat in the samples were determined using second-derivative spectrophotometry.

The laboratory recoveries determined for each replicate were combined to give a mean recovery for Tyvek, nylon, and cotton. These mean values were used to calculate corrected paraquat ion concentrations, unless the recoveries were ≥100%.

Results

Work practices

During the study, Gramoxone W was used for general weed control in and around the tea crop at a nominal application rate of 0.7 litres of product in 450 litres of water per ha (equivalent to 0.03% w/v). This is the lowest rate recommended for sparse weed infestation and accounts for roughly 90% of the total use of Gramoxone on JEDB estates; it is normal practice to apply pesticides between 07 h 00 and 13 h 00.

Mixing and loading involved two workers who alternated between handling the Gramoxone W formulation and filling the knapsack tanks. Their equipment consisted of a half oil-drum of nominal 91-litre capacity (20 gallons), a bucket, and a 283 ml (10 fl. oz) cut-down baby’s feeding bottle. On day 3 to days 5 and 6 a second oil-drum was used to improve the efficiency of mixing and loading, which increased the amounts of paraquat handled and sprayed compared with days 1 and 2.

The usual source of water for diluting the formulation was a stream close to the sites of spray application. One mixer–loader partly filled the mixing drum with water from the stream, decanted 142 ml (5 fl. oz) Gramoxone W into the measuring bottle, and poured it into the drum. The drum was then filled with water and the resultant spray dilution stirred using a stick. Individual knapsack tanks were filled to capacity from the drum using the bucket. A residual amount of spray solution was carried over from one batch of spray solution to the next, resulting in a progressive, slight increase in the concentration of paraquat over the working day.

The mixer–loaders often stood in the stream while they were adding water to the drum or handling the formulation; any spillages on the hands or legs were therefore washed off almost immediately. Overall, the standard of hygiene of the mixer–loaders was very high, despite their minimal working clothing and lack of protective equipment.

The operators sprayed only seven knapsack tanks each on day 1 and eight tanks each on days 2–6. This was because the weed infestation was sparse, the terrain hilly and often muddy, the spraying conducted among tea bushes up to 1 m in height, and considerable distances were involved in walking to and from the mixing–loading site. In view of this, the target set by the spray team supervisor was for each operator to treat about 0.4 ha per day.

Owing to the muddy conditions brought about by heavy rainfall, the operators usually washed their feet and legs when they reached the mixing–loading site. Under these conditions, the standard of hygiene of these workers was also high.

Amounts of paraquat handled or sprayed

The amounts of paraquat handled or sprayed increased from 20.8 g (day 1) to 45.4 g (days 4 and 5); however, there was consistency between spray operators on the same day. Also, the two mixer–loaders did not handle the same amounts of paraquat on days 1, 2 and 3; overall, the amounts of paraquat they handled lay in the range 95–113 g (day 1) to 227 g (days 4 and 5).

On the day of the dermal exposure assessment, in which four batches of spray solution were prepared and sprayed in each replicate, the amounts of paraquat handled and sprayed were equivalent in total to those used on days 4 and 5 (226 g by the mixer–loaders and 45.4 g by the spray operators).

Absorption of paraquat

No paraquat was detected in any of the urine samples (lower limit of detection, 0.03 μg paraquat per ml). Completeness of urine collection is verified by the volumes and the amounts of creatinine excreted (see Table 1). The overall average volume of urine (1.94 litres) indicates that the average amount of paraquat excreted was <58.2 μg per day.

Table 1: Daily volumes of urine collected and amounts of creatinine excreted by the 12 study workers

<table>
<thead>
<tr>
<th>Worker</th>
<th>Mean daily volume of urine (litres)×</th>
<th>Mean daily creatinine excretion (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.03 (1.60–2.65)</td>
<td>0.99 (0.75–1.40)</td>
</tr>
<tr>
<td>2</td>
<td>1.52 (0.95–2.00)</td>
<td>1.06 (0.68–1.40)</td>
</tr>
<tr>
<td>3</td>
<td>1.59 (1.20–1.80)</td>
<td>0.95 (0.69–1.10)</td>
</tr>
<tr>
<td>4</td>
<td>2.52 (2.10–2.90)</td>
<td>0.96 (0.61–1.20)</td>
</tr>
<tr>
<td>5</td>
<td>2.41 (1.30–3.00)</td>
<td>1.17 (0.74–2.80)</td>
</tr>
<tr>
<td>6</td>
<td>2.43 (1.80–3.45)</td>
<td>1.23 (0.95–1.50)</td>
</tr>
<tr>
<td>7</td>
<td>1.52 (0.80–2.74)</td>
<td>1.0 (0.63–1.20)</td>
</tr>
<tr>
<td>8</td>
<td>1.83 (1.00–2.55)</td>
<td>1.16 (0.97–1.50)</td>
</tr>
<tr>
<td>9</td>
<td>2.17 (1.50–2.85)</td>
<td>1.23 (0.89–1.40)</td>
</tr>
<tr>
<td>10</td>
<td>1.73 (0.80–2.35)</td>
<td>1.25 (0.99–1.50)</td>
</tr>
<tr>
<td>11</td>
<td>1.95 (1.30–2.50)</td>
<td>0.88 (0.64–1.10)</td>
</tr>
<tr>
<td>12</td>
<td>1.84 (0.95–2.50)</td>
<td>1.28 (1.10–1.50)</td>
</tr>
</tbody>
</table>

× Overall average urine volume: 1.94 litres per day.

a Figures in parentheses are the range.

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Recovery of paraquat from exposure sampling clothing

The average laboratory (procedural) recoveries of paraquat from the different materials were in the range 96–105%. Field recoveries were generally more variable, with two sets of anomalously low levels (socks (dark) and gloves (light): 40% and 49%, resp.); otherwise, the average recoveries for the different materials, kept in the dark or exposed to light, were 79–125% and 85–124%, respectively. There was no consistent difference between the recoveries of paraquat from material kept in the dark or exposed to light. Recoveries from formulation-fortified material tended to be higher than those from material fortified with spray solution.

Potential dermal exposure to paraquat

The procedural recovery of paraquat was excellent and no corrections were made to the potential dermal exposure data (see Table 2). The total potential exposure of the mixer–loaders was similar within each of the two replicates; however, the exposure in the second replicate was less than that in the first (mean values: 5.17 mg and 0.04 mg paraquat per g sprayed and 61 mg and 0.54 mg/g, resp.). The mean total potential exposure from mixing and loading an amount of paraquat equivalent to the maximum handled on days 4 and 5 (227 g paraquat) was 66.1 mg (0.29 mg/g).

The total potential exposure of the spray operators was consistent within and between the two replicates (mean ± SD: 33.2 ± 11.0 mg and 1.46 ± 0.49 mg/g paraquat ion sprayed compared with 40.5 ± 23.9 mg and 1.78 ± 1.05 mg/g sprayed); the overall range for both replicates was 18.4–104 mg and 0.81–4.58 mg/g. The mean total potential exposure to paraquat equivalent to the maximum amount sprayed during the absorption assessment (8 knapsack tanks, 45.4 g paraquat) was 73.7 ± 22.9 mg (1.62 ± 0.50 mg/g sprayed).

The hands of the mixer–loaders suffered the greatest exposure to paraquat (85.5%); in contrast, their feet and legs incurred 9.2%, and trunk and arms 5.1%. Thus about 95% of the total potential exposure would have been incurred by the skin directly, in the absence of the exposure sampling garments, since normal work clothing consisted of a short-sleeved shirt and shorts.

For the spray operators the exposure was as follows: hands (37.9%), legs (30.3%), and feet (24.3%), with the trunk and arms receiving 6.2%. Thus it is likely that about 90% of the total potential exposure would have been incurred by the skin directly, in the absence of the exposure sampling garments.

Weather conditions

The windspeed was generally low over the 6 days of spraying (range, 0–3.5 m/sec). The temperature in the shade was consistent and ranged from 21.5°C to 30°C throughout the periods of spraying. The relative humidity exhibited no consistent pattern and ranged from 34% to 92%. General weather conditions were usually clear and sunny or cloudy, with a tendency to cloud later in the morning on two occasions. There was rain towards the end of the last day of spraying when dermal exposure was assessed.

Discussion

The aim of the study was to establish the exposure to and absorption of paraquat by workers who were representative of those evaluated in the larger epidemiological study (/); therefore, it was important that the workers involved in the field study used paraquat as they would normally. In this regard, the typical rate of application of Gramoxone per ha was 0.7 litres in 450 litres of water (0.03% w/v paraquat ion).

The amounts of paraquat used and its concentration in the spray solution are lower than is usual in hand-held applications (for example, on Malaysian rubber/oil palm plantations); the nominal concentration of paraquat ion in our study was 0.3–0.4 g/l, compared with 1–2 g/l in Malaysia. The mean dilution of concentrated paraquat formulation found in a survey of Malaysian rubber and oil palm smallholders was 9.8 ml/l, equivalent to a concentration of 2.0 g/l (/0). The mixer–loaders and spray operators in our study wore their normal work clothing (shorts, shirts, no footwear) with no protective equipment, and the spray operators used their standard knapsack sprayers. These sprayers were fitted with double conejet nozzles, which are not recommended for spraying paraquat; however, since this nozzle is used routinely on JEDB Estates for application of paraquat, it was used also in the study.

In developing countries, paraquat is applied by plantation workers and smallholder farmers predominantly using manually operated knapsack sprayers.
For example, the vast majority of Malaysian and Thai smallholder farmers use knapsack sprayers to apply paraquat (10, 11); however, they typically wear long-sleeved shirts, long trousers, and rubber boots or shoes. Compliance with the use of protective gloves and eye protection when mixing the concentrated formulation was poor in the surveys of Malaysian and Thai smallholders, but better than that in the present study. In Central America (Guatemala, El Salvador, and Honduras), maize smallholders use manually operated knapsack sprayers (12) for paraquat but wear similar clothing to that described above for the Malaysian farmers; only in Guatemala was there any indication of "barefoot" application. Protective gloves and eye protection are not generally worn by maize smallholders when they mix concentrated paraquat formulations. In Colombia a significant proportion of rice farmers spray paraquat without footwear because the wet, sticky conditions after irrigation make the wearing of boots inconvenient (13).

In the above-mentioned surveys, the methods of measuring out concentrated paraquat formulations involved considerable improvisation—use of the product container cap, measuring cap, baby-feeding bottles, tin cans, etc.

Because of the nature of intermittent spot spraying for general weed control and the hilly terrain of the tea plantations in Sri Lanka, the number of knapsack tanks that an operator can spray in a working day is relatively low (8 per day), compared with the 13–15 per day in continuous strip spraying on Malaysian plantations. However, the smaller amounts of paraquat used per day in Sri Lanka are offset to some extent by the use of the double conejet nozzle, with its greater potential for exposure. Overall, the conditions and practices that prevailed in our study are typical of paraquat use in developing countries.

The mixer–loaders and the spray operators experienced, on average, roughly equivalent levels of dermal exposure (66 mg and 74 mg paraquat, respectively). For both these groups, more than 90% of the total dermal exposure was on uncovered parts of the body; however, the distribution of this exposure differed. The hands of the mixer–loaders accounted for about 86% of their total exposure, whereas the hands, legs, and feet of the spray operators were exposed in approximately equal proportions. The levels of dermal exposure were therefore representative of those incurred by the workers under normal conditions.

Despite the evidence of dermal exposure, no paraquat was detected in the urine of the workers (lower limit of determination of the method, 0.03 μg paraquat/ml). Only one other comparable report of the absorption of paraquat has appeared, in which two studies of Malaysian plantation workers who used paraquat for 12 weeks were described (14). The clothing worn by the workers consisted of a shirt or singlet, long trousers (tucked into their socks), and footwear, ranging from open sandals to leather boots;

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**Table 2: Total potential dermal exposure to paraquat of the 12 study workers**

<table>
<thead>
<tr>
<th>Worker</th>
<th>Task&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Replicate 1 (4 knapsack tanks)</th>
<th>Replicate 2 (4 knapsack tanks)</th>
<th>Total (8 knapsack tanks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mg</td>
<td>mg/g paraquat&lt;sup&gt;b&lt;/sup&gt;</td>
<td>mg</td>
</tr>
<tr>
<td>1</td>
<td>ML</td>
<td>67.4</td>
<td>0.60</td>
<td>4.50</td>
</tr>
<tr>
<td>2</td>
<td>ML</td>
<td>54.5</td>
<td>0.48</td>
<td>5.84</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>61.0</td>
<td>0.54</td>
<td>5.17</td>
</tr>
<tr>
<td>3</td>
<td>SO</td>
<td>18.9</td>
<td>0.83</td>
<td>104</td>
</tr>
<tr>
<td>4</td>
<td>SO</td>
<td>37.3</td>
<td>1.64</td>
<td>36.4</td>
</tr>
<tr>
<td>5</td>
<td>SO</td>
<td>25.9</td>
<td>1.14</td>
<td>40.8</td>
</tr>
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<td>6</td>
<td>SO</td>
<td>35.8</td>
<td>1.58</td>
<td>49.1</td>
</tr>
<tr>
<td>7</td>
<td>SO</td>
<td>31.7</td>
<td>1.40</td>
<td>35.7</td>
</tr>
<tr>
<td>8</td>
<td>SO</td>
<td>30.6</td>
<td>1.35</td>
<td>26.6</td>
</tr>
<tr>
<td>9</td>
<td>SO</td>
<td>24.3</td>
<td>1.07</td>
<td>18.4</td>
</tr>
<tr>
<td>10</td>
<td>SO</td>
<td>25.6</td>
<td>1.13</td>
<td>25.8</td>
</tr>
<tr>
<td>11</td>
<td>SO</td>
<td>55.5</td>
<td>2.44</td>
<td>36.3</td>
</tr>
<tr>
<td>12</td>
<td>SO</td>
<td>46.3</td>
<td>2.04</td>
<td>31.8</td>
</tr>
</tbody>
</table>

<sup>a</sup> ML = mixer–loader; SO = spray-operator.

<sup>b</sup> mg/g paraquat handled or sprayed.
urinary concentrations of paraquat were measured throughout the study and mostly were <0.1 μg/ml, with a maximum of 0.37 μg/ml.

Since the concentrations of paraquat in urine are always much higher than the corresponding levels in plasma, we can conclude that the levels of paraquat in plasma in the present study were <0.03 μg/ml, i.e., considerably less than the threshold (0.2 μg/ml) below which it does not accumulate in or cause damage to rat lungs (5). Since human and rat lungs behave similarly in terms of their uptake and release of paraquat, the study workers were probably not at risk of lung damage. This conclusion is supported by the findings of the associated epidemiological study (1), in which the results of the lung function tests for the study group of spray operators were similar to those of the control groups of factory and general workers. The extremely low level of absorption of paraquat was due partly to the very dilute spray solution (15). Of equal importance, however, was the high standard of personal hygiene employed by the workers, despite their minimal work clothing and lack of protective equipment when mixing and loading. Because they washed their hands, legs, and feet at frequent intervals, the workers would have removed most of the contaminating paraquat before it could be absorbed. These two factors, combined with the intrinsically low absorption of paraquat by skin (15, 16) could explain why the amounts absorbed by the workers were not measurable.

### Acknowledgements

The invaluable help and support of Dr. Guruanathan’s staff at JEDB Estates is gratefully acknowledged. We also thank the management of JEDB Estates for permission to carry out the study. The excellent technical support provided by A. Pereira and other individuals at Chemical Industries (Colombo) Ltd. and by Miss J.D. Mahler, ICI Central Toxicology Laboratory, is also gratefully acknowledged.

### Résumé

**Exposition professionnelle au paraquat chez des ouvriers des plantations de thé à Sri Lanka**

L’absorption du paraquat (1,1′-diméthyl-4,4′-bipyrindinium), un herbicide, par les ouvriers (mélangeurs-chargeurs et pulvérisateurs) d’une plantation de thé à Sri Lanka a été évaluée au cours de 5 jours consécutifs de pulvérisation. On a recueilli quotidiennement chez ces ouvriers les urines de 24 heures en commençant la veille des opérations de pulvérisation, puis chacun des 5 jours de ces opérations, puis encore pendant 7 jours.

L’exposition cutanée potentielle a été évaluée au cours d’autres applications de paraquat, le lendemain du dernier jour de collecte des urines. Deux opérations de pulvérisation ont été réalisées, au cours desquelles la quantité de paraquat manipulée ou pulvérisée était équivalente au maximum quotidien utilisé lors de l’évaluation de l’absorption.

Les ouvriers chargés du mélange et du chargement de l’herbicide et ceux chargés des pulvérisations ont subi en moyenne une exposition cutanée potentielle à peu près identique (respectivement 66 mg et 74 mg d’ion paraquat); toutefois, la répartition de l’exposition était différente. Chez les mélangeurs-chargeurs, environ 86% de l’exposition totale portait sur les mains, tandis que chez les pulvérisateurs environ 90% de l’exposition portait sur les mains, les jambes et les pieds, dans des proportions sensiblement égales. Dans les deux cas, au moins 90% de l’exposition potentielle totale concernait des parties du corps normalement découvertes.

Malgré les indices d’exposition cutanée, on n’a pas trouvé de paraquat dans l’urine des ouvriers. Cela s’explique probablement par le fait que la concentration de paraquat dans les solutions utilisées pour les pulvérisations ponctuelles dans les plantations de thé est très faible (0,3–0,4 g d’ion paraquat par litre), que les ouvriers observent une très bonne hygiène personnelle, et que la peau humaine est peu perméable au paraquat.

### References


