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Operator Exposure during Pesticide Application in Greenhouse

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Abstract: The aim of this study was to determine of dermal deposition on operator by patch method in fungicide application for tomatoes grown in greenhouse. The size of patches was 10x10 cm^2 and attached on operator's shoulder, chest, back, arm, forearm, thigh, leg, foot, ankle, hands and mask. Standard spray gun was used in trials. The operator sprayed distances of 200 m in greenhouse. Each trial was replicated three times. All patches on the operator were collected after trials and analyzed in the laboratory. Gas chromatograph equipped with electron capture detector (GC-ECD) was used in laboratory analysis. The operator was right-handed. In the conclusions of this study, the highest pesticide depositions were obtained on the left hand, foot and ankle. In addition, pesticide depositions on lower parts of the operator's body were 9.205% higher than upper parts of the operator's body. The total recovery was determined 52.2% for lower and 47.8% for upper body of operator. In the result of this study, it was concluded that for minimizing dermal deposition on operators, it should be worn gloves and footwear in pesticide applications with standard spray gun.
Keywords: Human health, operator exposure, dermal deposition, patch methods, pesticide contamination, spray gun

INTRODUCTION

In Turkey, greenhouses covers 49 741 ha according to data of 2006 [1]. In greenhouse, number of pesticide application is higher than in field. In 2004, 3 million people suffered from pesticide toxicity [2]. Dermal exposure to pesticides is highly linked with the manual touch with pesticides and it depends on the main route of pesticide absorption during occupational use [3]. Pesticide exposure of human is investigated considering the operator, the worker, and the bystander (Council Directive 91/414/EC). Operator is defined as any people who are primarily involved in pesticide application. Operator may be exposed to pesticides through the product landing on the skin, by inhalation or by accidental oral ingestion [4]. Therefore, operator directly expose to pesticide active ingredients. Operator exposure can be considerably reduced by using personnel protection equipment (PPE) [4, 5, 6, 7]. The using of PPE such as sleeved shirt, long pants, rubber boots, gloves, and apronreduces exposed dermal area of operator [8, 9, 10, 11, 12, 13, 14]. In Turkey, operator and worker usually do not use PPE (coveralls, sleeved shirt, long pants, gloves, footwear, aprons, respirators, eyewear and headwear) in spraying due to weather conditions in summer and do not take care of pesticide toxicity. Bozdogan and Yarpuz-Bozdogan[9] assessed that PPE reduced 36.3% the potential risk for worker in defoliant application. Claman[10] indicated that operators need to be awarned with clear labelling to minimize exposure to toxins by use of sleeved shirt, long pants, gloves and careful application methods during pesticide application. Pesticides can seriously negative effect on occupational health problems if appropriate spraying equipment and suitable PPE do not be used in greenhouse spraying due to indoor application. Therefore, suitable protective clothing and respiratory protection are needed during pesticide application in greenhouses [5]. The potential dermal exposure to pesticide sprays can be measured with whole body dosimetry method or with the patch method [16]. The patch method involves the use of a number of absorbent patches (gauze, cellulose paper, cotton fabric, etc.) of a defined size attached to different parts of the body [6, 16]. The aim of this study was to determine of pesticide contamination on operator via patch method of fungicide application in greenhouse. This study was the first one concerning dermal operator exposure to fungicide in greenhouse, in Turkey.

MATERIALS AND METHODS

The trials were carried out tomatoes grown in greenhouse (200 m^2). Tomatoes were planted one row and within-row distance was 90 cm. The height of the tomato plants was approximately 32 cm. In trials,

mancozeb was used as active ingredient (a. i.), and its dosage was 200 gram per 100 liters. Standard spray gun was used in trials. The standard spray gun is the most common spray equipment in the Adana province, Turkey. The operator walking speed was 4.5 km per hour. The spray pressure was 20 bar, and the average flow rate was 10.2 litres per minute. During the trials, the relative humidity and the temperature in the greenhouse were recorded. The relative humidity was 67 - 70 %, and temperature was measured 39.8 – 46.0 ^{o}C in greenhouse.

The dermal exposure of operator was measured using the patch method [6]. Cotton fabric patches (10 x 10 cm^2) were attached on shoulder, back, chest, arm and forearm, thigh, legs, foot, ankle, hands and mask of operator (Figure 1). After the spraying with standard spray gun, the patches were picked up and were placed in glass containers (500 ml) and brought away laboratory. Each patch was extracted using 150 ml volumes of methanol. The samples were shaken for 30 minutes in a water bath with a shaker at room temperature. A 1.7 ml fraction of each extract was sealed in a gas chromatograph vial and analysed.

Dermal deposition on operator was calculated by Eq 1 [12, 17].

$$Dermal\ Deposition\ (\mu g/kg) = \left[\frac{Measured\left(\frac{\mu g}{cm^2}\right) X\ Exposedarea(cm^2)}{70\ kgofbodyweight}\right] \text{----------eq-1.}$$

where, measured µg/cm^2 was the total value given for deposition, and exposed area was surface area of operator on the average of values for body parts (Table 1). In this study, the operator weight was 70 kg.

All chromatographic analysis was performed on a Perkin Elmer Company^{TM}Autosystem XL gas chromatograph equipped with electron capture detector (GC-ECD). The analytical procedure was applied according to GC methods [18].

SPSS 14.0 for Windows (SPSS, Chicago, IL, USA) was used for statistical analysis. Comparisons of the mean pesticide depositions were quantified by the one-way analysis of variance (ANOVA) at P<0.05.

RESULTS AND DISCUSSION

In this research, the total pesticide deposition on operator was 2.677 µg/kg by using Eq.1. In this study, the average deposition of mancozeba. i. on each body part were shown in Table 1.

As seen in Table 1, the depositions were determined as 21.948±1.202 ng/cm^2 on left hand and 17.489±0.811 ng/cm^2 on left ankle however the operator was right-handed. These values are higher than other part of the body of operator. In general, deposition on left part of body was higher than right part. The reason of high deposition on left part of body may be ossicillation of left arm while walking, and airstream occurs, and spray droplets may be captured on left parts of body whereas right hand is stable while using spray gun. Tuomainen *et al*.[5] showed that during pesticide mixing and loading in the greenhouses over 99 % of the potential dermal exposure was accounted for by the workers' hands. Machera *et al*.[16] obtained the similar results in greenhouse spraying. Nuyttens *et al*.[6] indicated that the highest exposure with the spray lance was obtained on hands. Bjugstad and Hermansen[19] reported that the potential operator exposure was significantly higher for a tunnel system compared with the open field system for strawberry and raspberry.

The total recovery (%) on operator according to upper (mask, shoulder, chest, back, upper and lower arm and, hands) and lower (thigh, lower leg, ankle and foot) body are shown in Figure2.

As seen in Figure2, the total recovery (%) found on lower body parts was higher than upper body parts. The total recovery was determined 52.197% for lower and 47.8% for upper body. Tuomainen *et al*.[5] showed that during the application period in greenhouse lower (60%) and upper (21%) were the body parts, which were mostly contaminated. The highest total recovery was obtained foot+ankle on lower and hands on upper body. The recovery was about 29.246% on the foot+ankle according to total recovery on lower body, and 16.329% on the hands of upper body's total recovery. The measured exposures of the feet+ankle were the highest because of contacting of falling droplets. Stamper *et al*.[20] showed that the most exposed areas was legs in greenhouse spraying. Accordingly, Stamper *et al*.[20] indicated that exposure to outside pads was primarily (84%) to the legs of the applicators in greenhouse. Nuyttens *et al*.[6] indicated that the highest pesticide exposure was obtained on feet in greenhouse. Yarpuz-Bozdogan *et al*.[21] showed that the highest pesticide residues in greenhouse were found on operator's knee and ankle in knapsack sprayer application. Nuyttens *et al*. [6] determined that the highest exposure was obtained on the lower body in greenhouse spraying.

The average deposits of pesticide on operator according to right and left side are shown in Figure3.

As seen in Figure 3, the highest pesticide deposits were obtained in the left hand. The main reason of this difference was the operator sprayed with right hand and the left hand moved so large spray droplets come into contact with the left hand. On the other hand, the highest exposure to pesticide was obtained on the ankle+foot. Because, sprayed droplets fall to the ground with the effect of the force of gravity and the foot and the ankle bring into contact with the

spray droplets. Vidal *et al*.[22] indicated that the highest exposure was determined on lower legs and front thighs of the operators in greenhouses. Nuyttens *et al*.[23] indicated that the exposure on the right side of the body was about four times smaller than on the left side of the body with the spray gun in greenhouse spraying. Cerruto *et al*.[24] found that the highest exposure occurs on legs in greenhouse applications. Dermal operator exposure in greenhouse can be minimized when the operators use PPE. Using of PPE in pesticide applications should be taken into account for occupational health [25].

Table1. Average pesticide residues (ng cm^{-2}) found in each one of the body part (Mean values±SD of four replicates)

Body Part		Mean values±SD (ng cm^{-2})	Total Recovery (%)
Mask		1.998±0.188	1.173
Chest		3.573±0.363	2.097
Back		4.212±0.797	2.472
Shoulder	Right	5.195±0.734	3.049
	Left	7.503±0.620	4.403
Upperarm	Right	7.047±0.471	4.136
	Left	7.523±0.237	4.415
Lowerarm	Right	8.805±0.665	5.167
	Left	7.766±0.139	4.558
Thigh	Right	8.116±0.905	4.763
	Left	12.623±0.774	7.408
Lower leg	Right	9.399±0.998	5.516
	Left	8.972±0.442	5.265
Ankle	Right	13.872±1.587	8.141
	Left	17.489±0.811	10.264
Foot	Right	8.105±1.305	4.756
	Left	10.369±1.282	6.085
Hand	Right	5.877±0.215	3.449
	Left	21.948±1.202	12.880
Total Pesticide Residues		**170.392**	**˜100**

Fig-1:Patches position on operator

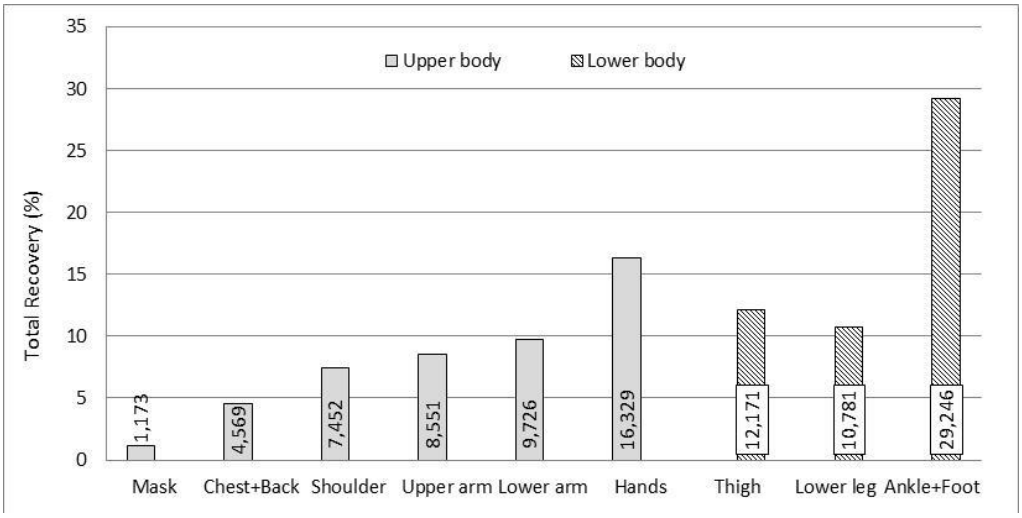

Fig-2: Total recovery (%) on operator according to upper and lower body

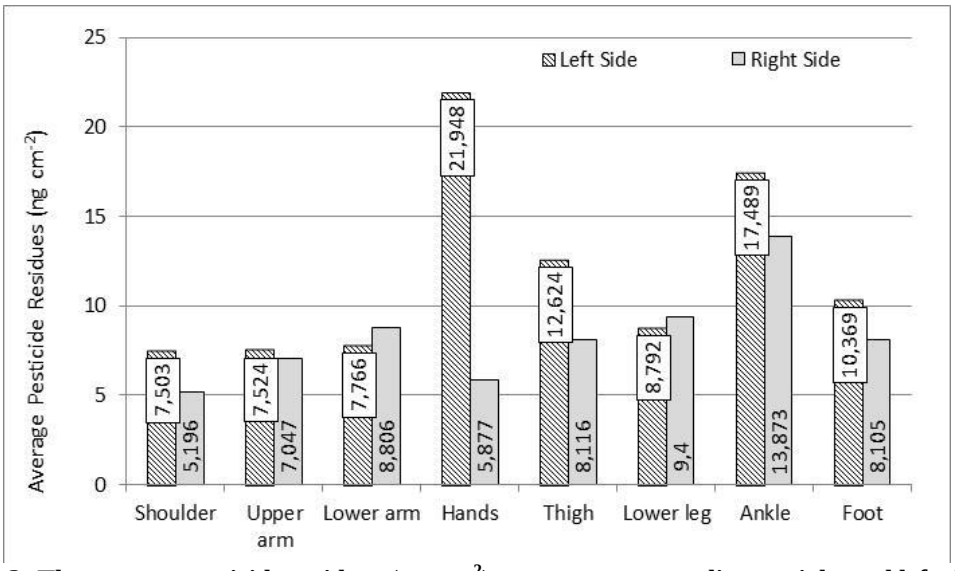

Fig-3: The average pesticide residues (ng cm^{-2}) on operator according to right and left side

CONCLUSIONS

In this study, the highest pesticide residues were obtained in the left hand. The average pesticide residues found on lower body parts (thigh, lower leg, ankle and foot) was higher than the average pesticide residues on upper body parts (mask, shoulder, chest, back, upper and lower arm and, hands). The measured exposures of the foot+ankle were the highest of the lower body because the foot and the ankle come into contact with the falling droplets. Exposure of pesticide operators can be decreased when they use PPE in greenhouse. Suitable PPE are needed during pesticide application in greenhouse. The operator exposure can be reduced by wearing PPE. Moreover, for operator and worker, special courses about relation between pesticide and negative effects on health and prevention against its effect have to be arranged in village. Also, in rural, their children at school-age have to take compulsory lesson about these subjects. It is important for healthy next-generation.

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