

Pesticide application over covered crops with hand held equipment: analysis of the contaminations¹.

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Abstract

The use of hand held equipments for treatments over covered crops produces, among the other, drawbacks connected to the risks of the workers (skin contacts with chemicals or their inhalation) above all when suitable PPE (personal protective equipments) are not worn.

The present paper reports the results of simulated treatment tests carried out in tunnels on strawberry crops, using a watery solution with a 2% concentration of food dyestuff.

The tests involved 3 types of hand held equipments connected with a hose to a pressure-driven atomizing sprayer, placed outside at the opening of the tunnels.

The measures regarded the deposits of dyestuff on the PPE worn by the workers during the tests and the «off-target» losses, measured by Petri capsules, placed on the ground, along the lanes where the workers walked. These deposits were then analysed with a spectrophotometer.

For all the tested equipments, the deposits registered on the PPE sensitively increase from the head, to the thorax, to the lower limbs, because of the "prostrated" vegetative behaviour of the crop, not more than 30 cm from the top of the ridge high.

Although the afore-mentioned equipments allow to carry out localized treatments on the ridge, considerable «off-target » losses were registered on the transit lanes. The amount of the losses along rows turned out unsteady and in inverse relation to the leaves deposits.

Keywords: exposure, strawberry covered crops, PPE, «Off-target » losses.

Introduction

The small sizes of the covered structures (numerous tunnels, covered with plastic sheets) (Baldoïn *et al.*, 2007), the "prostrated" vegetative behaviour and the products often resting on the ground, the high investment for hectare (from 7 to 9 plants/m²), the arrangement of lands into mulched ridges with plastic film, reduce the choice of the suitable sprayers in most the southern strawberry crop between these two types:

- sprayers equipped with diffuser "cannon", operating from either one of the openings at the ends of the tunnel;
- hand held equipments provided with one or more nozzles connected to ordinary mechanical sprayers by hose, placed outside the tunnel, driven by the operator along the narrow lanes ($\leq 0,40$ m), obtained between the twin rows (Guarella *et al.*, 2007).

These manual equipments, widely used in the recent past, are still utilized in particular conditions (small horticultural farms) and circumstances (especially virulent or hard to control

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parasitary attacks) (Oggero *et al.*,2008).

The use of hand held equipments produces drawbacks connected to the high times taken to carry out the treatments and to the workers' hazards (skin contacts with chemicals or their inhalation) above all when suitable PPE (personal protective equipments) are not worn.

The "cannon" sprayers, that allow greater safety for the workers as the afore mentioned risk of contamination is almost nil in normal operating situations, share with the hand held equipments the risk of environmental contaminations, because of the off-target losses along the lanes and, in case of incorrect positioning and adjustment of the cannon, the risk relating to the sprinkling of the inner surface of the protection cover (Guarella *et al.*, 2008).

From the normative point of view it needs to remember the Community, National and Regional Legislation, concerning the correct management of the pesticides; in particular, the D.L. 626/94, with the subsequent modifications and integrations, which forces the employer to draw up the risk prevention plan, by an evaluation of the hazards and the adoption of able measures to reduce or remove these and, more than recent, the D.L. 25/2002, concerning the putting into effect of the 98/24/ CEE directive about the «Protection of the health and safety of workers from the risks related to chemical agents at work».

Also the Food and Agriculture Organization of the United Nations (FAO), within the Inter-Organisation Programme for the Sound Management of Chemicals (IOMC), developed "The International Code of Conduct on the Distribution and Use of Pesticides", to provide a comprehensive standard for pesticide activities and a point of reference in relation to sound pesticide management practices. In June 2006 the "Guidelines on Monitoring and Observance of the Code of Conduct" were published.

This Code, among the other, urges the National Competent Authority to promote or support the use of methodologies and sprayer equipments able to reduce the operators' exposure to pesticides, also including the personal protective equipments.

These PPE differ from one another according to the category of risk which the worker is exposed (89/686/CEE Directive). For each one of the category to which the PPE belong there are: a) careful fulfilment for the introduction on the market (CE trademark, declaration of conformity, information concerning the conservation modes, use, cleaning, control and disinfection, technical performances, required fittings, level of insured protection, dates of expiry, etc); b) different methods to make a choice of the protective equipment in relation to the parts of the body (skin, eyes, respiratory and digestive tract), the typology and length of exposure (direct spray, solid or liquid dispersions, aerosol) and the sprayer (with or without knapsack, connected to the tractor with or without cab, etc).

With reference to the division of the covered crop, in the tunnel or the greenhouse, there are not in Italy systematic surveys concerning the health hazards of the workers rising from exposure to pesticides, above all during their distribution.

A survey carried out in Europe points out, in the Southern Nations, included Italy, worrying absorbable by the derma (up to 900 ml/h) amounts of pesticides as well as the possible fumes and/or powder in the air because of the bad management of the changes of air or non-fulfilment of the re-entry times (Glass *et al.*, 1999). However, the overall theme is quite well-known in his general terms:

- during the treatment the workers' contamination widely arise from the typology of the used sprayer and the arrangement of the target²;

² The employment of hand held equipments during treatments is the cause of the following contamination of the parts of the operator's body: hands (25%), trunk and head (25%), lower limbs (50%), according to the POEM (Predictive Operator Exposure Model) used for the evaluation of the workers' risks.

- the amount of the above-mentioned contamination is due to: a) the closeness between the worker and the spray, b) the direction of the spray, c) the worker's way of walking (for the hand held equipments): forwards or backwards;
- the re-entry times, the criteria ventilation (whether or not forced) and therefore the changes of air influence the contamination in greenhouses or tunnels (Tab. 1) (Van Os *et al.*,1994);
- the methods to make a choice with regard to the ergonomic-protective qualities and to the couplings (compatibility, complementarity) result from the effective circumstances, above all the typologies of worker's exposures (liquid or solid treatments, diameter of drops or granulometry of particles, volumes/ha, machines with or without knapsack, etc.).

The present paper reports the results of tests of simulated treatment carried out on strawberry crops in twin rows in tunnel in Basilicata, using three hand held sprayers. The aim of the research was the evaluation of the qualitative and quantitative contamination on the PPE worn by the workers in this area and the so called «off-target » losses along the lanes where the operators walked during the treatments.

Table 1. Minimum workers' re-entry times in greenhouses after treatments

Typology of distributed pesticides	Re-entry warned minimum times
All the products except those: irritant or sensitizing taking back in label the time specific of return	8 hours after the treatment, by ventilation of the environment ³
Irritant products, with risk sentence: R36, R38, R41	24 hours after the treatment, by ventilation of the environment ³
Sensitizing products, with risk sentence: R42, R43	48 hours after the treatment, by ventilation of the environment ³
Products with label mentioned re-entry times	Observance of the suggested re-entry times and use of the mentioned PPE

Source: *Ministry of the French Agriculture.*

Materials and methods

Simulated treatment tests were carried out in tunnels over strawberry crops, using a watery solution with a 2% concentration of food colouring (tartrazine). The land was arranged into mulched ridges with plastic black film.

The tests involved 3 types of hand held equipments (Fig.1), connected with a hose to a trailed pressure-driven atomizing sprayer, placed outside at the front opening of the tunnels and powered by the tractor's PTO. The examined machines were:

- a spray gun equipped with one nozzle (Fig. 1A);
- a boom segment with 2 nozzles (even flat spray tips) 25 cm spaced (Fig. 1B);
- an adjustable row application kit equipped with 3 differently positioned nozzles (even flat spray tips) (Fig. 1C).

The delivered volumes varied among 1200 ÷ 2800 l/ha with operating pressures of 1 or 2 MPa (Tab.2).

³ The prevention bodies suggest ventilating (forced ventilation) a closed environment (greenhouses) for 2 hours at least, in order to remove the molecules in suspension in the air, before the re-entry of the workers.



Figure 1. Tested hand held equipments: A - Spray gun; B - Boom segment; C - Adjustable row application kit

Table 2. Synoptic table of operating parameters adopted during tests

Description	Operating parameters
Spray gun	<ul style="list-style-type: none"> • nozzle flow rate: 5,2 l/min • operative pressure: 2 MPa • volume rate: 1633 l/ha
Boom segment	<ul style="list-style-type: none"> • overall nozzle flow rate: 13,1 l/min • operative pressure: 2 MPa • volume rate: 2785 l/ha
Adjustable row application kit	<ul style="list-style-type: none"> • nozzle flow rate: 3,84 l/min • operative pressure: 1 MPa • volume rate: 1226 l/ha

The measures regarded:

- the deposits of dyestuff on the PPE (disposable overalls, headwear, mask, gloves and shoe covers) worn by the workers during the tests. The afore-mentioned PPE were split and kept apart at the end of each simulated treatment, in order to evaluate the amount and the placement of the contamination (staining).
- the «off-target » losses, measured by Petri capsules, placed on the ground, along the lanes where the workers walked.

The deposits of dyestuff on the PPE and those relating to «off-target » losses were determined in the laboratory using a spectrophotometer.

Results and discussion

The hourly deposits mean values and the percentage ones of contamination measured at the different parts of the overalls and the other components of the PPE worn by the workers are reported in the Tab.3.

As expected, for all the tested equipments, the deposits registered on the PPE sensitively increase from the head, to the thorax, to the lower limbs, because of the "prostrated" vegetative behaviour of the crop, not more than 30 cm from the top of the ridge high.

Tab.3- Contamination on the parts of the overalls and PPE

	Spray gun		Boom segment		Row application kit	
	deposit		deposit		deposit	
	(%)	(ml/h)	(%)	(ml/h)	(%)	(ml/h)
headwear	0,7	0,9	0,5	2,7	0,2	2,5
mask	0,1	0,1	0,1	1,2	0,1	0,7
back	1,0	1,1	0,8	6,2	0,4	3,4
thorax	2,9	3,5	0,9	6,7	0,5	4,1
right arm	1,8	2,2	0,5	2,9	1,6	12,7
left arm	1,1	1,2	0,7	6,1	0,5	4,2
right glove	1,4	1,3	1,5	8,3	0,1	0,5
left glove	1,0	0,9	1,2	7,8	0,1	0,5
right leg	25,1	24,2	33,3	230,9	41,0	333,5
left leg	35,0	36,3	32,7	231,9	23,1	192,2
right foot	13,8	13,9	13,9	91,4	14,7	120,0
left foot	16,1	15,8	13,9	90,0	17,7	145,9
total	100,0	101,4	100,0	686,1	100,0	820,2

The hourly deposit and the percentage values measured at the mask are the lowest (0,1%), so the potential contamination for respiratory tract would turn out negligible. On the contrary the contamination for cutaneous passage, above all at legs and feet level, is by far prevailing (Fig.2): from 90% to 97% for the three tested equipments.

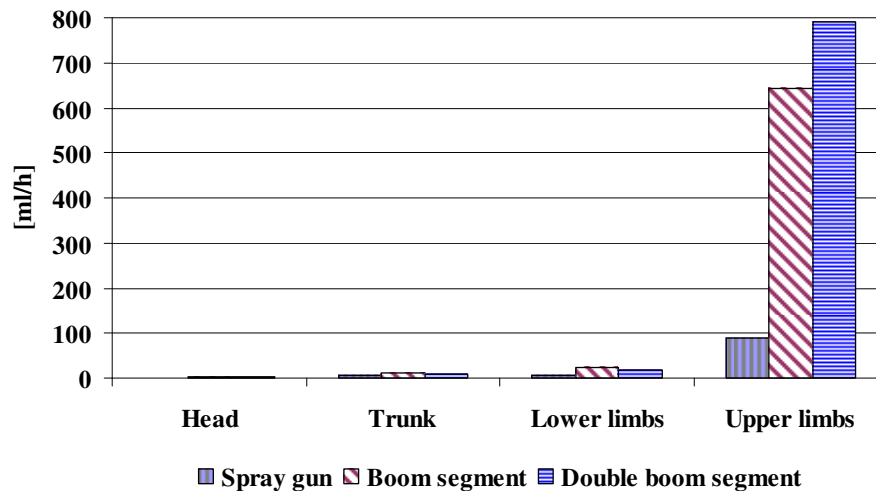


Figure 2. Hourly average deposits registered on the PPE, corresponding to the various parts of the workers' body

The hourly amounts of total deposit on the PPE are very different: about 100 ml/h with the spray gun, 690 ml/h with the boom segment and 820 ml/h with the adjustable row application kit.

There is not a clear correlation between the afore mentioned deposits and the delivered volumes and then the contamination prevalently results from: a) the closeness and direction of the spray as regards the worker's body; b) the manner of using the various equipments,

included the way of walking (forwards or backwards) in the lanes during the treatments.

Such reasons explain the asymmetrical deposits of dyestuff registered at the right/left and front/rear parts of the body.

The deposits registered in the lanes have been regarded as "ground losses", but not those ones obtained inside the ridge which can be useful for the product leaning on the mulched film, above all during the ripening.

Although the equipments allow to carry out localized treatments on the ridge, considerable «off-target» losses were registered on the transit lanes: from 1,84 $\mu\text{l}/\text{cm}^2$ (adjustable row application kit) to 2,80 $\mu\text{l}/\text{cm}^2$ (spray gun). This last value is higher than the average deposit measured on the leaves of the treated crop.

The amount of the losses along rows turned out unsteady and in inverse relation to the leaves deposits.

Conclusions

The amounts of the «off-target » losses and the staining of the PPE worn by the workers, registered during the simulated treatments over the strawberry crop, prove a common and widespread underestimation of the problem. This also appeared from a recent survey carried out in Italy, concerning the sprayers - more than 60% of the farms use manual lances - and the way of distributing the pesticides over the covered crops: although more than 80% of the interviewees stated to use the PPE during the distribution, only 50% of these PPE were suitable to the protection from the chemical agents (Cerruto *et al.*2007).

There is a prevailing concern in the operating situation of the sector: to assure, in any case, a uniform covering of the crops so that to obtain the best of protection, using the available equipments.

The experiences carried out in Italy and abroad, instead, prove that it is possible to make agree among distribution effectiveness, worker's safe guard from the chemical contaminations and the environmental protection from the punctiform pollutions, through suitable technological and operating choices and, in option, the use of fit machines and protection systems.

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