

Exposure to Pesticides: a Survey on Sicilian Greenhouse Operators

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Abstract

Greenhouses are microcosms aimed at providing physical environments suitable for increase growth and production of crops and pesticide application is a common practice to improve quality and quantity of agricultural products. Unfortunately, the enclosed conditions makes sure that greenhouse workers are more exposed to higher levels of plant protection products than general agricultural workers. This paper reports the results of a survey of pesticide application in greenhouses of South-East of Sicily carried out at the Department of Agricultural Engineering of the Catania University.

The survey covers several aspects: statistics on farms, machinery used, number of applications per year, operating parameters, operator safety, and environmental impact. The results show that the most widespread machinery is the hand held high pressure (20 bar) spray lance or spray gun. The majority of operators (62%) make more than 16 application per year, spraying volume rates ranging from 700 to 1000 L/ha. The machinery maintenance is very poor: 19 percent of pressure gauges were broken and 86 percent have never been checked, as well as 19 percent of nozzles and 43 percent of filters have never been replaced. The use of PPE isn't widespread as it should be: during mixture preparation, when concentrated pesticides are to be manipulated, only 43 percent of operators use waterproof gloves, 19 percent wear appropriate overalls, and 14 percent protects respiratory tract by means activated carbon masks. Finally, the attention towards environmental aspects isn't adequate, especially as regards the management of the waste products from pesticide applications (mixture remnants, water used for sprayer cleaning, empty containers).

Key words: safety, environment, spray lances

Introduction

According to the Italian Central Statistics Institute (ISTAT, 2006), in Italy there are some 35000 ha of vegetables (tomatoes, lettuces, zucchini) and some 5000 ha of ornamental (roses, chrysanthemums, carnations) protected crops. Sicily account for some 8800 ha and 430660 t, mainly located in the province of Ragusa (4750 ha and 272650 t). Greenhouses, given the peculiar structural and climatic conditions (confined space, high temperature, high relative humidity), are very specific agro-ecosystems with respect to the open field so, to ensure high productions, massive energetic and chemical (fertilizers and pesticides) inputs are necessary.

Therefore, greenhouse workers' exposure to pesticides is one of the main sanitary problems. A recent survey of the Superior Italian Public Healthcare Institute (Settimi *et al.*, 2007), reports 2798 instance of poisonings in Italy in 2005, among which 1280 are related to agricultural pesticides. The region with the highest occurrence is Sicily (223, the 17.4%), where the consumption of agrochemicals is very high (20000 t in 2005, the 12.80% of the overall Italian consumption). Moreover, the usually high values of temperature and relative

Research developed within the MIUR project *Machinery and their adjustment for a sustainable pest control in glasshouses*.

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humidity inside greenhouses make it unpleasant to wear proper protective equipment, so the risk of exposure can increase.

Exposure can occur during mixture preparation, its application to the crops, machinery cleaning, and post-treatment operations connected to the re-entry in greenhouse (Aprea *et al.*, 2002). Several Authors (Bjugstad and Torgrimsen, 1996; Tuomainen *et al.*, 2002; Garrido Frenich *et al.*, 2002; Cerruto *et al.*, 2009) report that the human exposure is affected by a number of factors: spraying equipment, operating mode, drop size, crop features. Surveys carried out in Turkey (Ergonen *et al.*, 2005), Spain (Sánchez-Hermosilla *et al.*, 1998) and Italy (Cerruto *et al.*, 2007) show that the handling of chemical products is done without taking all precautions to prevent exposures (inadequate use of personal protective equipment—PPE) and there is a marked unawareness about their danger and toxicity.

Moreover, pesticides have great impact on the environment (air, soil and water) (van der Werf, 1996) and contaminations can be both diffused (due to drift during the applications) and localised (due to mixture preparation and cleaning of the equipment usually in the same small area, not properly adequate). The recent European directive 128/2009/CE intends “establishing a framework for Community action to achieve the sustainable use of pesticides” and to this end encourages, among other things, the promotion of “research programmes aimed at determining the impacts of pesticide use on human health and the environment ... at European and national level”. Moreover, the directive 127/2009/CE imposes the necessity of using sprayers correctly regulated in order to minimise environmental hazards.

The present research is in agreement with these programs as reports the results of a survey carried out in the South-East of Sicily, where greenhouse crops are very widespread, that takes into account several aspects regarding operator safety and environmental contamination during pesticide applications in greenhouses.

Materials and Methods

A questionnaire was prepared and submitted to the owners of 21 greenhouse farms in the South-East of Sicily. It covered several aspects related to pesticide applications in greenhouse, among which:

- Farm statistics: cultivated areas, main crops, number, age, surface and structure of greenhouses;
- Machinery used: type of sprayer and its maintenance, nozzle type, tank capacity and mixing system;
- Operating parameters: type of pesticides, number of applications, volume rates, working pressure, walking direction when using spray lances;
- Operator safety: use of personal protective equipment (PPE) during loading and distribution of the mixture and during the post treatment operations (cleaning of the equipment);
- Environmental impact: management of empty containers of pesticides, remnants after treatments, and waste water.

The replies were statistically analysed, computing the distributions of the main quantities. All statistical analyses and graphical representations were carried out by means of the open source software R.

Results and Discussions

Farm statistics

The 21 farms surveyed are in the provinces of Ragusa (15), Siracusa (1), and Caltanissetta (5). Their cultivated area ranges from 1700 m² up to 12 ha, with a mean value of

3.19 ha; the area of 90 percent of them is less than 5.5 ha (Figure 1). Tomato is the most widespread crop, present in 20 out of 21 farms, and its surface extend over 43 out of 67 ha (64.2%), followed by zucchini (8 farms, 10.7 ha), eggplants (6 farms, 6.5 ha), and peppers (7 farms, 5.8 ha). Roses are present in only one farm, extending over 1 ha.

The number of greenhouses per farm ranges from 3 up to 21 and is related to the total cultivated area as reported in Figure 2. From the graph it emerges that when the total farm area is less than roughly 50 ha, the area covered by each greenhouse is about 2500 m², while in larger farms is about 5000 ha. The latter case refers to younger greenhouses (less than 6 years) with a metallic component in their shell, while the former refers to older greenhouses, mainly with concrete and wooden shell (Figure 3).

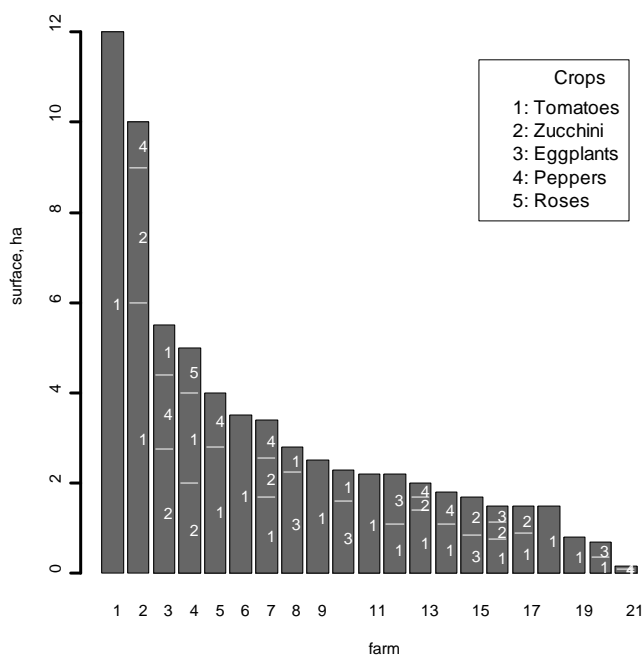


Figure 1. Cultivated area and crops present in the surveyed farms.

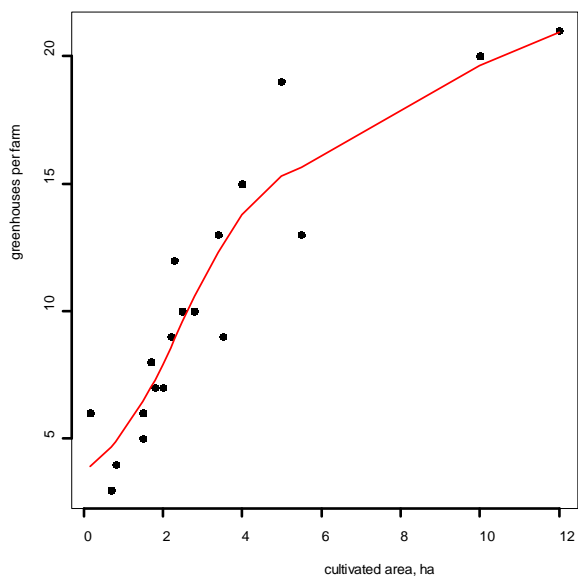


Figure 2. Number of greenhouses per farm vs. farm area.

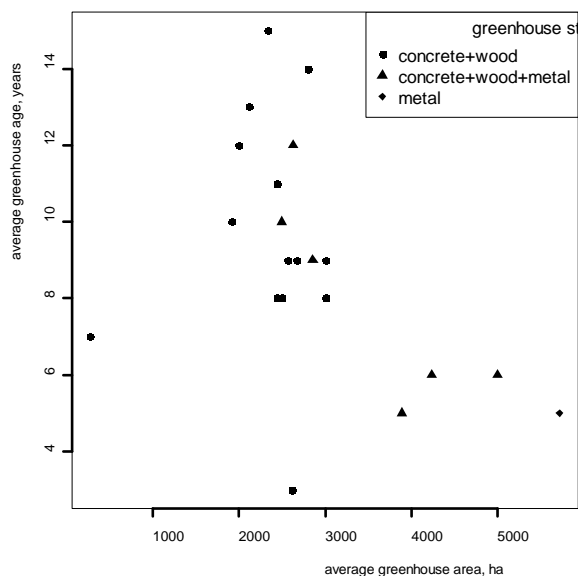


Figure 3. Age vs. greenhouse area.

Spraying machinery

In all surveyed farms, pesticide application is performed by means of hand held high pressure spray lances or spray guns, whose length ranges from 45 to 80 cm (mean 55 cm). In most cases (67%) the pump is fixed, whereas in other cases (33%) it is driven by the power take off (pto) of a tractor. Small farms (roughly below 3 ha) use fixed pumps, whereas larger

farms use pumps driven by pto (Figure 4). The pump age ranges from 3 up to 15 years (mean 8.9 years) and the lance age from 2 up to 12 years (mean 5.7). Almost always (88%) the pump age is greater than the lance age (Figure 4). The spray lance is mostly (90%) equipped with 2 turbulence nozzles and in other cases with only one nozzle. The nozzle material is mainly steel (35%), followed by brass (25%), ceramic (25%) and synthetic. The mixture tank capacity ranges from 200 to 1000 L: small tanks (around 200 L) are metallic, whereas the bigger ones are made with fibreglass (33%) and polyethylene (57%) (Figure 5). Tank capacity and farm area are quite uncorrelated (Figure 5). Finally, the mixture mixing is realized manually (62%) or hydraulically (38%).

Working parameters

Pesticide applications, both fungicides and insecticides-acaricides, are performed almost all over the year in all farms (in 94% for more than 9 months per year). In detail, 40 percent of the interviewed carry out between 10 and 15 treatments per year, 52 percent between 16 and 20, and 8% more than 20.

The spraying time ranges from 40 to 60 minutes per 1000 m² of treated area, with the greatest percentage (71%) from 40 to 45 minutes (Figure 6 a). The working pressure ranges from 10 to 20 bar (48% from 18 to 20 bar, Figure 6 b), and the volume rate from 700 to 1000 L/ha (52% from 750 to 800 L/ha, Figure 6 c).

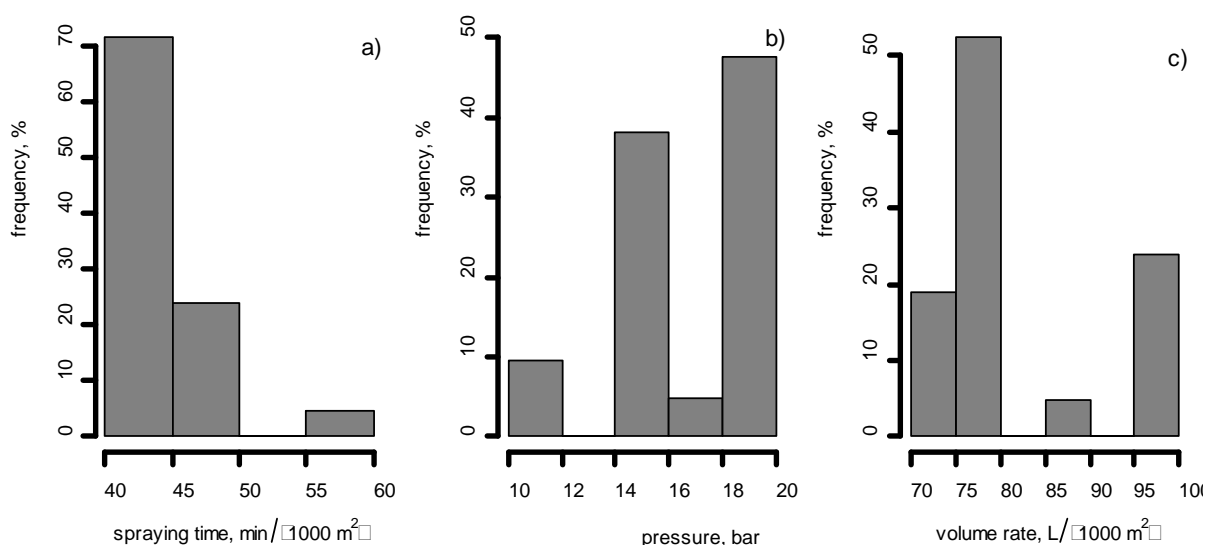


Figure 6. Main working parameters.

Operator safety

Pesticide application by means of spray lances is usually carried out by two operators: the former sprays the crops by moving amidst the rows and using the lance, the latter unwinds and rewinds the feeding hose-pipe. During spraying, the operator walks forward, even if this operating mode greatly increases his/her dermal exposure with respect to the walking backwards (Cerruto *et al.*, 2009).

In all the surveyed cases, operators were male, whose age ranged from 24 to 45 years. Their safety was assessed by analysing the re-entry time in greenhouse after treatments and, mainly, the use of personal protective equipment (PPE) during the main phases of a pesticide application: mixture preparation, mixture application, post-treatment operations (cleaning of equipment). The re-entry time was on average 15 hours, ranging from 2 to 24 hours. Fifty percent of the interviewed answered they went into the greenhouses for crop activities in the treated area 24 hours after spraying.

The use of PPE is summarized in Figure 7. From it emerges that a high percentage of operators don't wear appropriate PPE during the three phases took into consideration. For example, during the preparation of the mixture, when concentrated pesticides are to be manipulated, operators don't use at all gloves (19%), or use latex (24%) or textile (14%) gloves (textile gloves, when wet with pesticide, can become very risky). Moreover, no one protects his/her lower limbs by means of boots, and only 19 percent wear appropriate waterproof overalls for body protection (57 percent wear textiles boiler suit and 24 percent

don't wear any specific PPE for body protection). Even lower is the head protection: 85 percent of operators don't wear any PPE, while the others wear inappropriate hoods or caps. The protection of respiratory tract during mixture preparation is also very low: only 14 percent of operators use activated carbon masks, while 5 percent wear simple respirators and 81 percent any protection.

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view, the same study shows that, while spraying 1000 L/ha on full developed tomato plants, the operator's body collects about 220 mL/h of mixture. The greatest increase in using PPE is observed in protecting the respiratory tract: the use of activated carbon masks, in fact, increases from 14 to 81 percent (from 5 to 14 percent that of respirators).

Finally, the post-treatment operations (cleaning of the equipment) is considered the less dangerous phase, as the percentage of operators that don't wear PPE at all is the highest: hands (81%), body (48%), head (100%), and respiratory tract protection (95%).

Environmental aspects

The environmental aspects here considered regard cleaning and management of the empty containers of pesticides and management of residual mixture after treatments and waste water after cleaning sprayers.

All the operators clean the containers of pesticides and add the washing water to the mixture, but only 48 percent transfer the empty container to specialised collecting centres for their correct disposal (the others—52%—don't provide any reply). All the operators declare that when treatment is finished, a certain amount of mixture remains unsprayed inside the tank and this remnant is reused for next application, even if this operating mode could imply miscalculations in pesticide concentration if added to a new mixture. The majority of operators (86%) wash the spraying equipment, but with highly variable frequency: randomly (56%), when change active ingredient (33%), at the end of crop season (11%). The amount of used water isn't monitored and it is drained on the ground, without any caution, so increasing the risk of pollution from point sources.

Conclusions

The survey highlights some aspects of pesticide application in greenhouses of South-East Sicily that can be so summarized:

- high number of spray applications per year (60 percent more than 16);
- very poor level of mechanization, as the prevailing equipment is the hand held high pressure spray lance, with one or two turbulence nozzles;
- high working pressures (48 percent from 18 to 20 bar) and high volume rates (from 700 to 1000 L/ha and more, according to plant growth and pest severity);
- poor knowledge of the effective working parameters as the pressure gauge is broken (19%) or not visible during spray applications (24%) or never checked (86%);
- poor maintenance of the spraying equipment: use of brass-made nozzles, very subject to wear and tear (25%), non-substitution of nozzles and filtering devices since many years or not at all (19% and 43%, respectively), irregular cleaning;
- little regard for safety aspects, especially during mixture preparation, when concentrated pesticides are to be manipulated: high percentages of operators, ranging from 24 to 85 percent, no make use at all of personal protection equipment for body, hands, head, and respiratory tract. Mixture application is considered more dangerous than mixture preparation, as the percentage of operators that wear PPE is always higher;
- not adequate attention towards environmental aspects, especially those related to the management of the waste products from pesticide applications (mixture remnants, water used for sprayer cleaning, empty containers).

This general picture shows that pesticide application in greenhouses should be improved, increasing the professional know-how of the operators through specific training courses and requiring a mandatory inspection of the sprayers. Both aspects are examined by the cited European directives 127 and 128/2009/CE, which are expected to play an important

role in the direction of research and innovation for sprayers and crop protection in a more eco-compatible agriculture (Balsari and Oggero, 2009).

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