Emissions of plant protection products to air for protected crops

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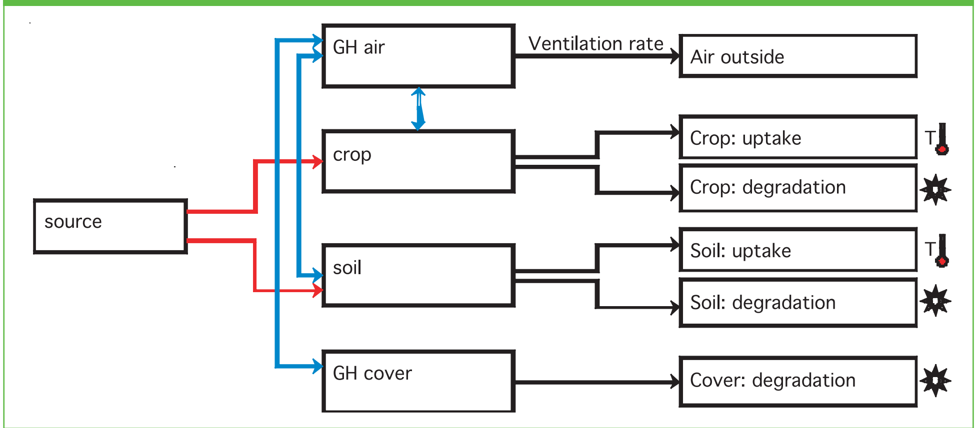
The presented research is part of a project commissioned by EFSA in order to obtain scientific information for the development of new EU guidance on emissions of plant protection products (PPPs) from protected crops. Emissions to the air outside covered structures are mainly caused by loss of volatilized PPPs through windows and other openings in the covered structures. The newly developed VEGA model (Ventilated Emissions from Greenhouse to Air) describes the fate of PPPs after a spray application inside covered structures. Figure 1 shows a schematic view of the model. It computes the concentration of PPP vapour in the greenhouse air by a set of differential equations that describe the processes of sedimentation, volatilization, absorbance, degradation and ventilation as a function of time. Key factors are dimensions of the greenhouse, its ventilation rate (depending on outdoor wind speed and opening fraction of the vents), crop height and LAI, physical properties of the PPP, indoor climate of the greenhouse.

Figure 1 - Schematic view of the VEGA model. Boxes marked with T represent temperature dependent processes; boxes marked with a small sun pictogram represent processes that are dependent on solar radiation

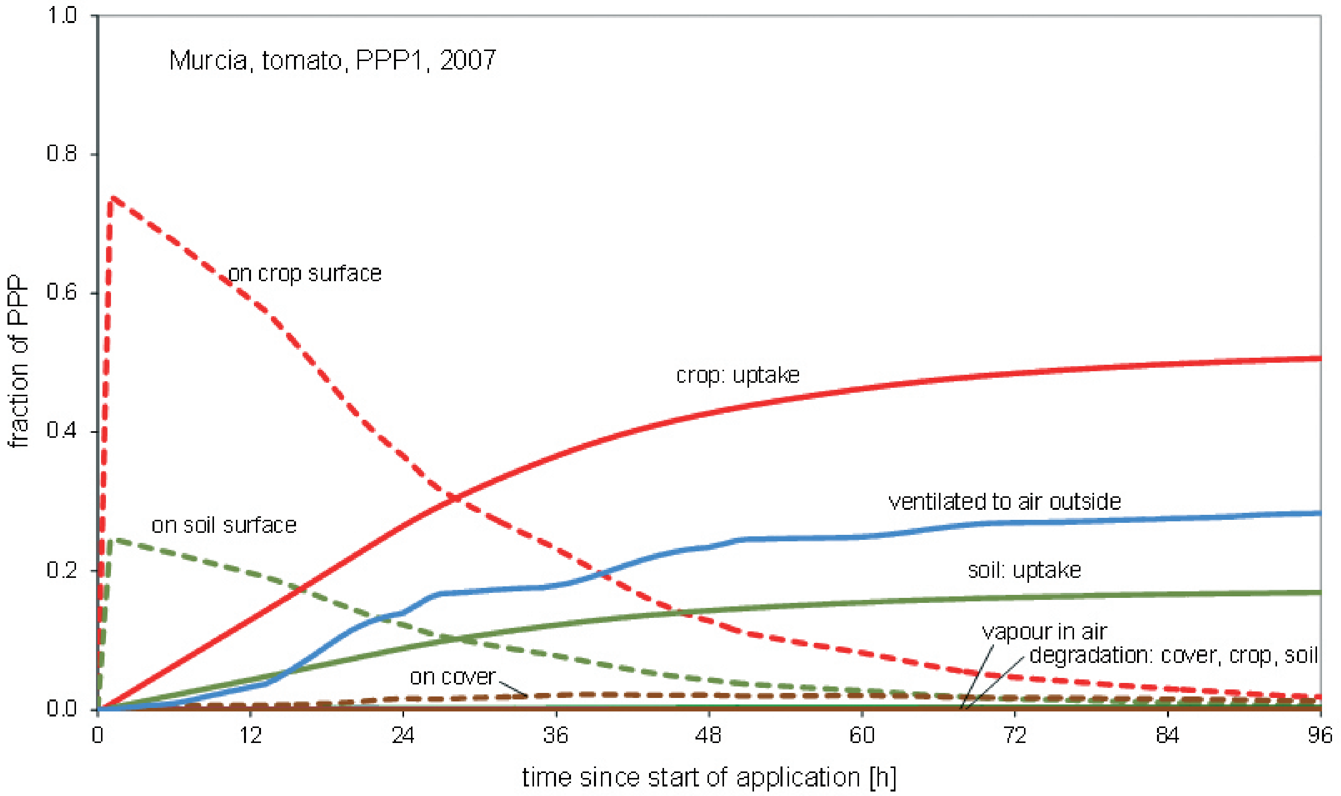


In this study a multi-span greenhouse and a walk-in tunnel were selected where a tomato crop or lettuce crop was grown. The structures were assumed to be located in southern Europe (Spain, Italy). Indoor climate and ventilation strategy were computed using the KASPRO model (De Zwart, 1996) based on 13 years of Spanish outdoor weather data. Two PPPs were selected, one with a relatively high vapour pressure (indicated as PPP_1; $5{\cdot}10^{-4}$ Pa) and one with relatively low vapour pressure (PPP_2; $7{\cdot}10^{-9}$ Pa). For the walk-in tunnel, which has a relatively open cover, an estimate was made of spray drift leaving the tunnel during the spray application. A comparison was made with outdoor volatilization using the CONSENSUS PEARL model (Van den Berg & Leistra, 2004) and open-field spray drift using the IDEFICS model (Holterman et al., 1997).

The model results for PPP_2 showed no significant emissions to air, due to the low vapour pressure. Figure 2 gives an example of the whereabouts of PPP1 during 96 hours since the spray application (during the first hour) in a multi-span greenhouse with a tomato crop. This example shows that eventually about 30% of the initially applied PPP is ventilated to the air outside. The other 70% is fixed to the crop and soil (indicated as 'uptake'). However, this fraction strongly depends on the half-lives for uptake chosen. Degradation appeared to be only a minor factor in the process, primarily due to the fact that solar radiation is not a constant and the upper leaves in the crop attenuate the radiation level rapidly.

Average spray drift losses from the walk-in tunnel over 13 years were estimated as 0.6% of the total amount of spray applied to a 1-ha area of tunnels, assuming that only drift from the tunnel at the downwind field edge leaves the area whereas drift from the remaining tunnels is deposited within the area. This is in the same order of magnitude as spray drift from an open-field application. Apparently, the higher potential for spray drift in the open-field situation is compensated roughly by the use of coarser nozzles than in those used in the walk-in tunnel.

Figure 2 - Whereabouts of PPP1 during 96 hours since start of application in a multi-span greenhouse with a tomato crop, Murcia, 2007. Dashed lines indicate fractions on temporary locations, solid lines indicate those at the accumulating final locations



Volatilization losses for the open-field situation were estimated typically below 10% of the applied volume of PPP. The observed differences between the results of the VEGA model and the PEARL model are not well understood and need further investigation.

To conclude, the results indicate that volatilization losses from covered structures in Southern Europe can be significant. The major factors involved are saturated vapour pressure of the PPP, ventilation rate of the covered structure, and climate data during the first few days after application. For structures with a high ventilation rate, such as the walk-in tunnel, exchange rates related to volatilization, condensation, uptake and degradation can be important as well. In all cases that were considered, volatilization losses exceeded losses due to spray drift by far. Consequently, the development of specific risk assessment scenarios for emissions from covered structures to air may be advisable.

KEY WORDS: Pesticides, protected crops, greenhouse, volatilization, drift, risk assessment, model

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