Workers’ exposition to aerosol during the sowing operations with pneumatic precision drills

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Abstract
Pneumatic precision drills used in the sowing of dressed maize (Zea mays L.) seed contribute to the diffusion in the environment of dust containing pesticides. The environment and the operators can be exposed to abrasion dust during the sowing operations. The paper shows the first results of trials aimed at assessing the potential quantity of pesticide that an operator can inhale during the sowing operations of maize treated with the neonicotinoid insecticide clothianidin. The amount of inhalable dust was recorded by means of personal air samplers, applied to the operator during the operations of seed loading and sawing. In the meantime the dust drift was observed with air samplers placed at the field edge and on the tractor. The total amount of dust potentially inhaled by the operator during the entire sowing was about 2 ng min$^{-1}$, with a maximum of 25 ng min$^{-1}$ during the loading of seed period. These data are relevant for risk assessment.

Keywords: dust, pesticides, aerosol particulate, operator exposure, safety

Introduction
In recent years it has been reported that pneumatic precision drills used in the sowing of maize (Zea mays L.) contribute to the diffusion in the environment of particulate matters derived from seed dressing (or coating) containing pesticides. The problem was particularly relevant for its effects on honey bees (Apis mellifera L.) and other pollinating insect populations (Apenet, 2011; Pochi et al., 2012). On the other hand, the operators (and bystanders and residents as well) are potentially exposed during the sowing to abrasion dust, and this exposure is therefore relevant for risk assessment. It can occur differently, such as during the manipulation of dressed seed (opening seed sacks and filling the drill) or in field, during the sowing, at the tractor seat. Different factors can affect the magnitude of the phenomenon, such as the presence of a closed cab on the tractor or of devices reducing abrasion dust dispersion. During sowing activities of treated seed, the main routes of exposure are dermal adsorption and inhalation. Dermal exposure to pesticides can occur during contact with the treated seeds and through contact with contaminated equipment or through deposition on the skin. Inhalation exposure may occur as a result of drift of particles abraded from seeds and additionally, from solid or dried pesticides from the treated seeds that become airborne or from soil contaminated with residues after the sowing with treated seeds. This secondary drift from contaminated soil is not considered relevant for the farmer exposure. Oral exposure may occur secondarily to dermal exposure, through hand to mouth transfer. This is especially relevant for infants or toddlers playing on contaminated surfaces. However, for farmers, the
maximum potential exposure by this route is generally assumed to be negligible in comparison with that via the skin and by inhalation.

The paper reports the results of first tests aimed at investigating the potential workers’ exposure to chemical risk during the sowing of dressed maize.

Materials and methods

Seed
The trials were carried out using commercial maize seed (Pioneer Hybreed PR32G44) dressed with the insecticide Poncho™, a.i.: clothianidin and with a fungicide (Celest™, a.i.: fludioxonil and metalaxyl). According to the manufacturer, the quantity of clothianidin was 1.250 mg seed⁻¹. The seed was packed in sacks (25,000 seeds sack⁻¹). A total of 12 sacks, corresponding to 96 kg of seed, was loaded and sowed.

A six-row precision pneumatic drill “Gaspardo Magica” was employed. The drill was implemented with a prototype, developed at CRA-ING, consisting of an innovative air-recycling/filtering system (Apenet, 2011, Pochi et al., 2011), capable to significantly reduce the emissions of dust in the atmosphere respect to the conventional drill.

Field test
The trials have been carried out in the experimental farms of CRA-ING (around 42°5’51.26”; N 12°37’3.52”E; 24 m a.s.l.) on 12th July 2011. During the tests, the meteorological parameters were monitored with a portable weather meter Kestrel 4500, with a sampling rate of 1 min.

A plot of about 3 ha was sowed. Four air samplers (TCR Tecora mod. Bravo) were used to collect samples of the powder present in the air. The samplers were equipped with 0.45 μm PTFE Millipore diskette filters (diameter 47 mm). The air sampling height was 2.0 m. They were placed at a distance of 5 m from the edge of the field and spaced 10 m. Considering the prevailing wind direction at the beginning of the trial they were placed leeward. They were calibrated with a constant flow of 15 L min⁻¹. The time needed for the sowing was about 65 min. After the sowing, the samplers were maintained in use for an additional time of about 15 min in order to allow the dispersion and the deposition of most of the dust, so a total volume of about 1200 L of air was sampled. An additional portable air sampler (Supelco Pas 3000) operating at 2.4 L min⁻¹ was placed on the tractor near the air inlet of the cab.

In order to detect the powder potentially inhaled by the operator, two portable samplers were applied to the operator, as showed in Fig. 1. The first (Supelco Pas 3000) was adjusted at an air flowrate of 2.7 L min⁻¹, and operated the sampling during the interval of time of 3 min required by the loading of the seed on the trolleys. The second sampler (SKC) was adjusted at an air flowrate of 2.25 L min⁻¹. In this case, the sampling lasted for the entire sowing operation, for a total time of 70 min. The three portable samplers were equipped with 0.45 μm PTFE Millipore diskette filters (diameter 37 mm).

Chemical analyses
The active ingredient determination in the filters was made at CRA-PAV. Active substances were extracted from the samples with acetonitrile. Solutions were sonicated in an ultrasonic bath for 10 min, then filtered with HPLC 0.45 μm filters. The analytical determinations were carried out by means of HPLC - ESI - MS – MS and the relative methods were validated in compliance with GLP procedures.
Results
The Table 1 shows the micrometeorological conditions recorded during the trial. The pesticide residue concentrations in the air and the quantity of potentially inhaled clothianidin are shown in Table 2. The amounts potentially inhalable by the operator are reported separately, with reference to the above mentioned phases of seed loading and sowing in the field, and as total.

The use of the innovative prototype confirmed low values (0.097 ppb) of air concentration of the active ingredient, recorded at 5 m from the field edge. In fact, in previous studies carried out with the same dressed seed and with the same drill equipped with air deflector, the recorded values ranged from a minimum of 0.139 ppb obtained in field plot of 0.16 ha to a maximum of 0.445 in plot of about 3 ha (Pochi et al., 2012).

Table 1. Micrometeorological conditions during the test

<table>
<thead>
<tr>
<th>Operation</th>
<th>Air temperature [°C]</th>
<th>Relative humidity [%]</th>
<th>Wind speed [m sec⁻¹]</th>
<th>Prevailing direction of wind</th>
<th>Barometric pressure [mb]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed loading</td>
<td>31.6</td>
<td>43.2</td>
<td>0.4</td>
<td>SSE</td>
<td>1011</td>
</tr>
<tr>
<td>Sowing</td>
<td>32.6</td>
<td>41.4</td>
<td>1.1</td>
<td>SE</td>
<td>1011</td>
</tr>
</tbody>
</table>

Table 2. Air concentrations of clothianidin and amounts potentially inhalable by the operator.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Field edge</td>
<td>Loading and sowing</td>
<td>~ 15</td>
<td>82</td>
<td>0.097</td>
<td>-</td>
</tr>
<tr>
<td>On the tractor</td>
<td>Loading and sowing</td>
<td>2.40</td>
<td>55</td>
<td>0.111</td>
<td>-</td>
</tr>
<tr>
<td>Operator</td>
<td>Loading</td>
<td>2.70</td>
<td>3</td>
<td>2.861</td>
<td>75</td>
</tr>
<tr>
<td>Operator</td>
<td>Loading and sowing</td>
<td>2.25</td>
<td>70</td>
<td>0.240</td>
<td>147</td>
</tr>
<tr>
<td>Operator</td>
<td>Sowing</td>
<td>-</td>
<td>67</td>
<td>0.098</td>
<td>72 (*)</td>
</tr>
</tbody>
</table>

(*) The amount is calculated by difference between the total detected amount in the filter for the entire sowing and the amount in the filter for the seed loading operation only.

Conclusions
The amount of potentially inhalable dust containing clothianidin derived from the dressed seed of maize was assessed during field trials. The results of the test showed the presence of low concentration of active ingredient in the air in the area leeward the test plot, as a consequence of the introduction of the CRA-ING prototype. Despite this, the analyses of the filters of the portable air samplers revealed appreciable amounts of active ingredients to which the operator was exposed by inhalation. The seed loading seems to be the most important phase, contributing to about 50% of the total powder inhalable by the operator, even if it takes only a few minutes. However, even during the sowing a fraction of dust reached the operator, despite of the presence of the cab. These observations suggest that attention should be paid to the exposure of the operator to dust containing residues of pesticides under different conditions of work and to the potential
risks for the health from longer times of exposure. The reported values of inhalable dust are referred to a relatively short interval of time and to the presence of an effective device for the reduction of dust dispersion. They could significantly increase under real operative conditions in which, for example, a contractor performs the sowing of maize for at least 8 hours a day, for a period of two months a year, handling quintals of seed in the filling operations. Under these conditions, the use of DPI is appropriate, but probably they would not eliminate the exposure to dust and more effective devices reducing dust could contribute to reduce the risk, together with new techniques and procedures for the seed loading, capable to avoid the escape of the abrasion dust.

Figure 1. Position of personal samplers on the operator

Acknowledgements
The authors are grateful to Gino Brannetti, Cesare Cervellini, Renato Grilli and Giancarlo Imperi for their collaboration during the field trials.

References