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Indoor assessment of dust drift effect from different types of pneumatic seed drills

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ABSTRACT

The air stream generated by the fan of pneumatic seeders – necessary to create a depression in the sowing element of the machine and to guarantee correct seed deposition – can blow away solid particles that have become detached from the seeds including the pesticide seed coating used for seed dressings. In this study, experimental tests were carried out to evaluate the performance of technical solutions by seeder manufacturers to limit dust drift. A specific test methodology was developed to assess seeder performance. The tested technologies that convey the air to the soil, independent of their design, reduced particle drift from seeds by more than 60% compared to a conventional machine with the fan outlet oriented upwards. Particle drift was reduced by more than 70% if only an area between 5 and 20 m downwind of the machine border was considered. This study has shown that the use of an appropriate design can reduce the dispersion of toxic seed coating dust in the atmosphere during seeding and that the methodology developed to carry out the trials could be used for seeder dust dispersion classification.

1. Introduction

Dust dispersion from seed drills during sowing of pesticide treated seeds is considered an important environmental problem. In fact, when pneumatic seeders are used to apply neonicotinoid insecticide dressed maize seeds, a dispersion of solid particles containing the insecticides may be generated in the areas surrounding the seeded fields (Baldessari et al., 2008; Altmann, 2003; Schnier et al., 2003). All the seed drills produce a fine dust due to the abrasions of the seed coating that occurs inside the seeding element. The air stream generated by the fan of pneumatic seeders – necessary to create a depression in the sowing element of the machine and to guarantee a correct seed deposition – can blow away the solid particles detached from the seeds (Balsari et al., 2010, 2013).

In recent years, research stations have developed different solutions for classifying the seed drill "dust dispersion" in the atmosphere. One method used to determine the dust quantity emitted from the fans of seed drills is similar to that typically used for agricultural sprayers (Rautmann et al., 2009). This method is described in the ISO 22866 standard and requires the trials to be carried out in the field, operating with constant wind speed (at least 1 m s^{-1}) and constant wind direction (transverse to the seeder's forward direction) and simulating the seeding operation over a surface area of 1 ha. These environmental condition requirements, however, are very difficult to meet and the tests often require several days work with consequent high costs.

Another method used consists of inserting the seed drill in a wind tunnel to simulate the seeding operation. In this case the wind is produced by a fan and the dust is collected by positioning Petri dishes at different distances downwind the machine (Biocca et al., 2011). This method, however, also has some problems because the seeding elements are not inserted in the soil as happens in the field, resulting in unrealistic over-estimates of dust drift. Furthermore, with this method it is necessary to use dressed seed, which is hazardous for operators.

The present study was therefore set up to develop a new experimental method aimed at assessing dust drift from maize seeders, overcoming the problems encountered applying the other test methods described above.

2. Materials and methods

2.1. Tests made

Tests were conducted in order to assess the dust dispersion from different pneumatic seed drills. For each sowing machine tested, the amount of dust deposit at different downwind distances from the seed drill was determined using a specific developed methodology.

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Table 1
Physical characteristics of the dust dressed seed and tracer Tartrazine E104.

Size particles	Dressed seed	Tartrazine E102
D_{10} (μm)	34.1	42.6
D_{50} (μm)	84.1	80.1
D_{90} (μm)	180.9	172.3
Density (g cm^{-3})	0.41	0.44

Table 2
Main technical features of the fans present on the pneumatic seeders tested.

Manufacturer	1	2	3
Seeding elements (n°)	6	6	6
Fan diameter (mm)	440	410	420
Fan width (mm)	45	60	80
Blades (n°)	10	10	8
Blade inclination (°)	30	31	0
Blade width (mm)	30	30	45
Air outlet size (mm)	105 × 45	230 × 60	135 × 80
Air direction	Lateral	Downwards	Upwards
Fan rotation speed (rev min^{-1})	5000	5400	4500
Air velocity (m s^{-1})	3.2	2.2	4.4
Air flow rate (m^3 h^{-1})	240	210	210

2.2. *The developed methodology*

The methodology set up consists in simulating in a wind tunnel the environmental air stream produced by an axial fan and downwind collection of the tracer emitted from the seeder's fan outlet.

A specific yellow dust tracer (Tartrazine E 102) was used in the trials because it showed physical characteristics similar to those of the dust dispersed by the fan of pneumatic seed drills operating with dressed seeds (Table 1). Use of this tracer allowed tests to be done in indoor conditions without specific precautions.

The tunnel, 5 m wide, 3 m high and 50 m long, was made with a modular iron structure covered with nylon film (Fig. 1). At one side of the tunnel an axial fan of 490 mm diameter and with 9 blades inclined at 50° was positioned. The air stream generated by the fan was emitted from one side of the seeder that was positioned in the middle of the tunnel. Tracer dust deposits were then collected on Petri dishes placed on the ground at different downwind distances from the machine.

In order to guarantee a uniform air stream, in all the tunnel areas close to the seeders tested, the machines were always positioned at 22 m distance from the axial fan outlet.

Inside the tunnel, downwind from the seeder position, arrays of 5 artificial collectors (Petri dishes, 138 mm diameter) were placed on the ground at distances of 1, 3, 5, 15 and 20 m from the downwind edge of the machine. In each array, Petri dishes were placed at 1 m spacing (Fig. 1).

Tests were conducted using the sowing machines with seeds in their hoppers and, after filling, the disc of the seeding element, adopting the fan revolution speed recommended by the manufacturer and employing 4 or 6 seeding elements, was inserted into the soil at a depth of 44–50 mm. The seed drills were run in a static position, using the tracer to simulate the seed dressing. The tracer was introduced in the fan air inlet at a rate of 3 g min^{-1} for 10 min by means of a volumetric powder feeder (BHT® BD20) with the axial fan activated. The experiment was replicated placing the sowing machine in both forward directions: position A – machine with fan outlet upwind – and position B – machine with fan outlet downwind because each seed drill model tested was equipped with a different fan design (outlet air direction, flow rate intensity, fan position…) (Fig. 1).

The amount of tracer deposited on each Petri dish was determined in laboratory by spectrophotometry analysis. Contaminated samplers were washed with 50 ml of deionised water and washings were then analysed with a spectrophotometer (Biochrom Lybra S11) set up at a wavelength of 434 nm, corresponding to the peak of absorption of the dye. The absorbance value read on the instrument enabled the corresponding amount of tracer to be calculated.

In order to verify the applicability of the methodology proposed, the uniformity of the artificial air stream in the tunnel and the repeatability of measurements of tracer deposits were assessed.

The air velocity was measured with a professional anemometer (Allemano Testo 400) that was mounted on a rigid support. Instrument accuracy was ±0.2 m s^{-1} and data were acquired at 1 Hz frequency. The measuring points were determined by drawing a 0.5 × 0.5 m grid in the transversal section of the tunnel at a distance of 20 m from the axial fan (close to the position of the sowing machine). At each point, the air velocity was determined on the basis of the arithmetical average value of 30 s of acquisition. The repeatability of the measurements of tracer deposits on Petri dishes was evaluated by determining the coefficient of variation (CV) calculated on 3 replicates for each collector position.

In order to estimate the global balance between the amount of tracer introduced in the fan of the sowing machine and the amount collected out of the seeder, a specific test was made using a conventional pneumatic seeder (Gaspardo Marta).

Collectors made of cellulose material (Camfil CM360), 200 × 100 mm size, were placed in five different sampling areas: 1) on the frame of the machine, 2) on the ground underneath the seeders, 3) on the ground at downwind distances of 1, 3, 5, 10, 15 and 20 m from the machine, 4) on the tunnel walls and 5) on a grid located at the exit of the tunnel. The amount of tracer deposited on each collector was determined in laboratory by spectrophotometry analysis as described above. To estimate the total amount of tracer deposited in each sampling area, the average collector deposit was projected over the corresponding total surface.

We have separated the results value obtained in the area from 1 to 20 m (as specified in European Standard ISO 22866) from those obtained in the 5–20 m zone (5 m is the minimum buffer zone request by several European countries) to highlight the differences of the contamination reduction.

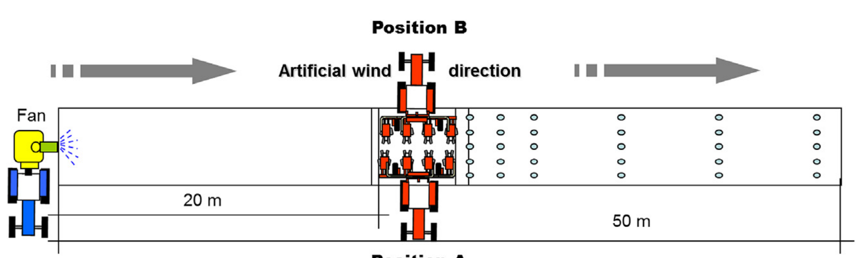

Fig. 1. - Scheme of the equipment disposition in the tunnel during the test.