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Performance evaluation of a cyclone to clean the air exiting from pneumatic seed drills during maize sowing

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A B S T R A C T

Seed dressings that control pests by the application of small doses of neonicotinoids directly on the seed are used on a large variety of crops. Although this system is efficient and inexpensive, in recent years it has been banned in the EU because small amounts of dust abraded from the seed coating can be released into the atmosphere by sowing machines, *which* kills non-target insects *including honey bees*. Bayer Crop Science® has developed *a device* to clean the air at the exit of the drill's fan (patented as SweepAir®). This system is able to separate the dust from the exhaust airflow and convey it into the soil while the cleaned air is returned to the atmosphere. This paper reports experimental tests on the performance of this system using tracer materials to simulate the seed dressing dust.

The tests showed that the cyclone system effectively separated 99.4% of the inert material, and it did not negatively impact drill performance. The tested kit reduced the contaminated superficial soil area *by close to 100%* and eliminated dust drift because the abraded seed dust was effectively inserted into the soil. In addition, this system can improve operator and environmental safety because the external surface of the drill *was* not contaminated by pesticides.

1. Introduction

Toxic substances can be released into the atmosphere as a result of agricultural processes, especially those linked to fuel consumption during cultivation (Blengini and Busto, 2009; Snyder et al., 2009; Safa and Samarasinghe, 2012) and to the use of pesticides (Lichiheb et al., 2014).

Seed dressing that controls pests by the application of small doses of pesticides directly on the seed is used on a large variety of crops (Elbert et al., 2008). Although this system is efficient and inexpensive, in recent years it has been restricted for some chemicals (e.g. neonicotinoids) because small amounts of dust abraded from the seed coating can be released into the atmosphere by sowing machines which kills insects that are not harmful to crops including important benefits insects including honey bees (Nuyttens et al., 2013).

Because the seed coating is abraded inside the seeding element, all seed drills produce a fine dust that could contaminate the environment. This is especially true for pneumatic drills, where an air stream generated by a fan is necessary to create a vacuum in the drill's sowing element. The air stream can blow solid dust particles detached from treated seeds *towards* areas adjacent to the field (Altmann, 2003; Greatti et al., 2003; Schnier et al., 2003; Greatti et al., 2006; Baldessari et al., 2008; Girolami et al., 2009).

Various authors have studied this phenomenon and have measured dust emission or dust drift potential under controlled and repeatable conditions by different methods (Giffard and Dupont, 2009; Biocca et al., 2011; Balsari et al., 2013; Manzone et al., 2014). Based on those results, drills were classified according to drift risk (Rautmann et al., 2009; Herbst et al., 2010).

In the past few years, several technical solutions applicable to pneumatic drills were developed to address this problem, but none of them was able to completely eliminate dust dispersion. These devices were able to contain 80% of the dust dispersed within the drill contour (Manzone et al., 2014).

Adopting some precautions during sowing activities also can reduce pesticide dispersion. Balsari et al. (2013) report that environmental contamination due to maize seed dressing can be reduced if pneumatic drills use lower fan revolution speeds. If the fan revolution speed is decreased by 1000 rev min^{-1} (corresponding to decreasing the PTO by 100 rev min^{-1}), airflow rate and fan air speed are decreased by 30%, significantly reducing the

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surface contaminated by the seed dressing material and also guaranteeing necessary depression of the seeding elements.

Previous technical solutions directed the exhaust airflow from the drill outlet toward the soil but did not eliminate the risk of environmental contamination. Therefore, Bayer CropScience® has developed *a device* to clean the air at the exit of the drill's fan (patented as SweepAir®). This system is able to separate the dust from the exhaust airflow and convey it into the soil while the cleaned air is returned to the atmosphere (Vrbka et al., 2014; Chapple et al., 2014). This paper reports experimental tests on the performance of *this system*.

2. Materials

2.1. The tested system

The main component of the tested system is the cyclone, a device able to separate dust from the airflow. Exhausted air from the pneumatic drill's fan is conveyed through a "primary pipe" with an 85 mm internal diameter that connects the fan outlet to the cyclone inlet. The pesticide dust is separated from the airflow in the cyclone. The clean air is moved upward in the cyclone and emitted into the atmosphere through a "secondary pipe" with a 150 mm internal diameter. The dust is conveyed downwards in the cyclone and then deposited into the soil by the furrow system. A rotary vacuum valve is installed between the cyclone and the furrow system. This valve ensures that the cyclone system properly functions and guarantees that the collected dust is discharged only when the furrow is in the soil (Fig. 1).

2.2. Drill used in the trials

Trials were conducted with a conventional pneumatic drill normally used for maize sowing in Europe (Gaspardo®MARTA). During the tests, the drill was configured with four and six seeding elements and with fertilizer hoppers (Fig. 2). The drill was set to sow 75,000 seed ha^{-1} with a distance between the seeding elements of 0.75 m (Table 1). During the test, in order to fix the tested kit to the drill, a specific support able to maintain in vertical position *the cyclone was provided on its frame*. Rotary valve was moved directly by the shaft used to power all seeding elements. This movement *was held in place by a* steel chain.

3. Methods

Two series of tests were performed to assess the system's performance. *Firstly*, the *efficiency of the system* was determined: 1) cyclone dust separation efficiency, 2) vacuum rotary valve life and 3) furrow system efficiency. Second, the influence of the system on the drill performance was evaluated: 4) fan airflow rate and vacuum level inside the seeding elements. Tests 3 and 4 were performed with and without the kit on the sowing machine.

Tests were performed without dressed maize seeds but using a *defined* tracer amount to simulate the seed dressing dust. This choice *allowed elimination of the* variability in the amount of dust abraded from the coated seeds during each test and to have reproducible test conditions for all the trials.

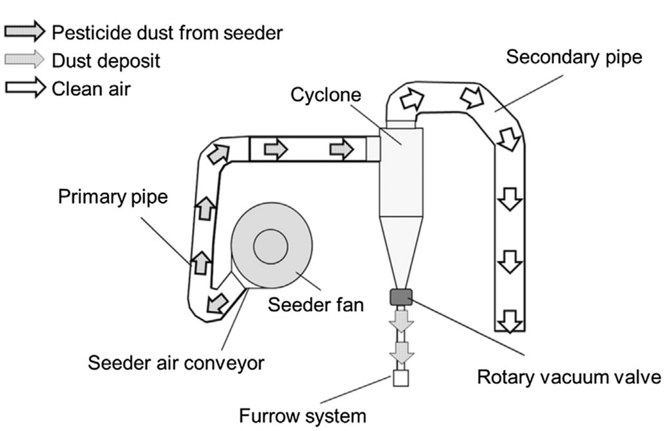

Fig. 1. SweepAir® system schematic.

Fig. 2. Drill used in the trials with the SweepAir® mounted.

3.1. Cyclone dust separation efficiency

The cyclone dust separation efficiency was evaluated using a mass balance method. The difference between the mass of tracer inserted into the kit and the amount intercepted by the cyclone system was measured. Because an inert material was used, the tests could be conducted without specific operator safety precautions.

Table 1
Pneumatic drill test configuration.

Manufacturer	Gaspardo®MARTA
Seeding elements (n°)	4–6
Fertilizer hoppers (n°)	2
Fan diameter (mm)	410
Fan width (mm)	60
Blades (n°)	10
Blade inclination (°)	31
Blade width (mm)	30
Air outlet size (mm)	230 × 60
Air direction	Downwards
Fan rotation speed (rev min^{-1})	5400

Table 2
Particle sizes of the dust dressed seed, wheat flour "00" and tracer Tartrazine E104.

Size particles	Dust of dressed seed	Wheat flour "00"	Tartrazine E102
D_{10} (μm)	34.1	35.4	42.6
D_{50} (μm)	84.1	74.1	80.1
D_{90} (μm)	180.9	163.5	172.3
Density (g cm^{-3})	0.41	0.45	0.44

Note: No significant difference – Statistical analysis ANOVA unvaried, $p > 0.05$.