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An innovative device to reduce dust dispersion from pneumatic seed drills during maize sowing operations

Marco Manzone, Paolo Balsari*, Paolo Marucco, Mario Tamagnone

University of Turin - DISAFA – Largo Braccini, 2, Grugliasco, 10095, Italy

Abstract

The air stream generated by the fan of pneumatic seeders necessary to create the depression in the sowing element of the machine, is considered responsible for blowing some solid dust particles detached from treated seeds towards the areas adjacent to the field. In order to solve this problem several technical solutions applicable to pneumatic seeders have been developed in the last years, but none of them was able to completely eliminate the dust dispersion. This paper reports experimental tests to study the constructive and operative parameters of an innovative device. The capability to eliminate dust dispersion during maize sowing operations has been studied as well. In this prototype, a cyclone is used to clean the air coming from the sowing elements. The collected solid dust particles are then discharged into the soil by mean of a specific controlled valve. To test this new solution, the device has been mounted on a maize pneumatic seeder equipped with 6 seeding elements and set to seed 75,000 seed ha-1. The main targets of these tests, were first to evaluate the influence of the device on the seeder's performances and then the determination of the amount of dispersed dust. The results showed that the use of this new device was able to reduce the drift of solid dust particles up to 100% and did not influence the performances of the seeder.

Keywords: Dressed seed; dust dispersion; SweepAir®; performances.

1. Introduction

Seed dressing controls pests by the application of small doses of pesticides directly on the seed; this is a technique used in a large variety of crops (Elbert et al, 2008). Although this system is efficient and inexpensive, in recent years, it has been banned because small particles of abraded dust from the seed coating can be released into the atmosphere by sowing machines and kill other insects not harmful to crops (Nuyttens et al, 2013).

*Corresponding Author: paolo.balsari@unito.it
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All the seed drills produce a fine dust - due to the abrasions of the seed coating that occurs inside the seeding element - which could contaminate the environment. This occurs especially in pneumatic seeders where an air stream generated by the fan is necessary to create the vacuum in the sowing element of the machine. This dust dispersion could be relevant and considered responsible for blowing some solid dust particles detached from treated seeds towards the areas adjacent to the field (Baldessari et al., 2008; Girolami et al., 2009; Greatti et al., 2006; Altmann, 2003; Schnier et al., 2003; Greatti et al., 2003).

In order to solve this problem several technical solutions applicable to pneumatic seeders have been developed in the last years, but none of them was able to completely eliminate the dust dispersion. The use of these devices resulted in 80% of dust generated being contained within the ground area of the air stream generated by the fan (Manzone et al., 2014).

Furthermore, the drift effect could be reduced also adopting same precautions during sowing operations. In a study, Balsari et al. (2013) report that it is possible to reduce the environmental contamination due to maize seeds dressing if lower fan revolution speeds are adopted on the pneumatic seeders. Decreasing by 1000 rev min-1 this parameter (that corresponds to a decreasing of 100 rev min-1 of the PTO), allowed to reduce by 30% the air flow rate and the air velocity generated by the fan and therefore to significantly limit the surface contaminated by the seeds dressing material, guaranteeing at the same time the necessary depression in the seeding elements.

Technical solutions developed until now convey exhaust air flow in seeders outlet towards the soil only and they are not in able to eliminate the risk of environmental contaminations. On the basis of this, Bayer CropScience has developed an innovative device to clean the air in exit of seeder's fan (patented SweepAir®). In fact, this innovative system is able to separate the dust from exhaust air flow and to covey it into the soil, while the air cleaned comes back in atmosphere (Vrbka et al, 2014; Chapple et al, 2014).

This paper reports the results obtained from experimental tests carried out to study the performances of SweepAir® system.

2. Materials

2.1 New system tested

The innovative technical solution tested has been developed at Bayer CropScience (BCS) and patented as SweepAir®.

The mainly component of SweepAir® system is the cyclone; a device that is able to separate the dust from air flow. Exhausted air in exit from the fan of pneumatic seed drills is convoyed in a "primary pipe" with 85 mm internal diameter, that connects the fan outlet to cyclone inlet. Here, the dust pesticide is separated from air flow. The clean air coming out upwards of the cyclone comes back in atmosphere through a "secondary pipe" with 150 mm internal diameter. The dust is conveyed downwards the cyclone and, successively, it is disposed into the soil by furrow system. A rotary vacuum valve is installed between the cyclone and the furrow system for two reasons. First, the valve is necessary to ensure the correct work of the cyclone system, and second to guarantee the dust output only when the furrow is in the soil (Fig. 1).

2.2 Seed drill used in the trials

Trials were carried out with a conventional pneumatic seed drill normally used for maize sowing in Europe contest (Gaspardo®MARTA). During the tests, the seeder has been configured with 4 and 6 seeding elements and with hoppers of the fertilizer system. Furthermore, it was set to sow 75,000 seed ha^{-1} with a distance between seeding element of 0.75 meters.

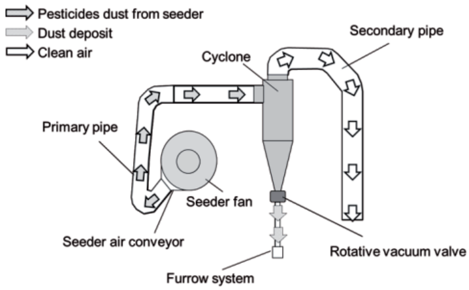


Fig. 1. Scheme of the main components of SweepAir® kit.

3. Methods

Tests were carried out in order to assess the SweepAir® system performances. In detail, it was measured: 1) cyclone dust separation efficiency; 2) fan air flow rate and vacuum level inside the seeding elements; 3) air velocity under and around of the seeder; 4) footprint under the seeder; and 5) dust drift downwind.

3.1. Cyclone dust separation efficiency

The cyclone dust separation efficiency has been evaluated using a mass balance method. In detail, it has been calculated the difference between the amount of tracer inserted in the SweepAir® kit and the amount intercepted by the cyclone system. Trials were carried out with a tracer because it allowed tests to be done without specific safety precautions.

The tracer to be used in the tests was wheat flour "00" type, because this material shows the physical characteristics most similar to the dressing seed material and therefore it can be used to assess the dust dispersion from the sowing machines (Balsari et al., 2013).

During the tests, 42 mbar vacuum level inside the seeding element has been kept, a value that according to Bragatto (2008) is considered optimal for correct maize sowing.

An amount of 100 g of tracer (at a rate of 3 g per minute) has been introduced into the inlet air stream of the cyclone.

3.2 Fan air flow rate and vacuum level inside the seeding element

Tests were carried out with the seed drills in static position according to methods set up by Balsari et al. (2013). The fan air flow rate was measured at the fan outlet using a 110 mm diameter conveyor 1 m long where a propeller anemometer (Allemano Testo 400) with 0,1 m s^{-1} accuracy was positioned.

The vacuum level in the seeding element was measured through a water manometer placed in the connection hose between the seeding element and the fan. In particular, the water manometer was made with two vertical tube characterized by 16 mm internal diameter and 2 meters height. The distance of the two different water level was determined using a ruler with 1 mm accuracy.

Tests were made using the seeder with 4 and 6 seeding elements, and with and without the Sweep Air® kit installed.

All measurements were carried out adopting a PTO revolution speed of 540 rev min^{-1}.

3.3 Air velocity under and around the seeder

The measurement was assessed with the seeders in static position and placed indoor, using the propeller anemometer (Allemano Testo 400) with 0,1 m s^{-1} precision mounted on a rigid support and making measurements at different heights from the ground. Air velocity was measured at heights of 0.05, 0.50, and 1.00 m at steps of 0.30 m under and around the seeder with and without SweepAir® kit according to Balsari et al. (2013).

In all tests, for each measuring point, the anemometer was conveniently oriented with respect to air stream, in order to detect the maximum air velocity. Tests were conducted using the fan revolution speed recommended by the manufacturer (540 rev min^{-1}) and using 4 and 6 seeding elements.

3.4 Footprint of the dust material

In order to measure the footprint of the dust material dispersed from the seeders, tests were carried out in the laboratory simulating the seeding operation with the machine in static position and using a tracer instead of the insecticide seed dressing material (Balsari et al., 2013).

Wheat flour tracer was then introduced in the fan air inlet at a rate of 3 g per minute and the material dispersed on the ground was determined by weight collecting it on Petri dishes (138 mm diameter) positioned at intervals of 100 mm under and around the seeders until a distance of 4 meters from the machine itself. In each test, a 30 g of tracer were used because this quantity is sufficient for the successive analysis.

3.5 Dust deposit downwind

Dust deposit in downwind zone has been evaluated following the methodology set up by Manzone et al. (2014). This methodology 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 dust yellow tracer (Tartrazine E 102), simulating the dust dispersed by the fan of pneumatic seed drills operating with dressed seeds, was used.

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.

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.

The tracer was introduced in the fan air inlet at a rate of 3 g min^{-1} for 10 minutes by means of a volumetric powder feeder (BHT® BD20) with the axial fan activated.

4 Results

4.1 Cyclone dust separation efficiency

Data processed showed a not total dust interception of the cyclone (Table 1). In fact, during the tests, the cyclone collected only the 99,4% or 99.6% depending if the seeds presence into the hopper was considered (table 1). The presence of a value higher than 100 g (amount introduced in each test) highlights a potential dust deposit inside the cyclone that at the same time can be tear away by the cyclone.

Table 1 – Tracer collected by cyclone.

Test	mean (g)	min (g)	max (g)	DS	IQR	Efficiency (%)
with seeds	99.6	99.2	100.0	0.4	0.7	99.6
without seeds	99.4	98.8	100.1	0.7	1.1	99.4

SD = Standard Deviation; IQR = Interquartile range. Statistical analysis could not detect any significant difference between test with and without seeds in the hopper

4.2 Fan air flow rate and vacuum level in the seeding element

The air flow rate was not different when measured with the seed drills in standard configuration and equipped with SweepAir Kit. Values were different only in function of the number of seeding elements with which the sowing machine was equipped (Fig. 2).

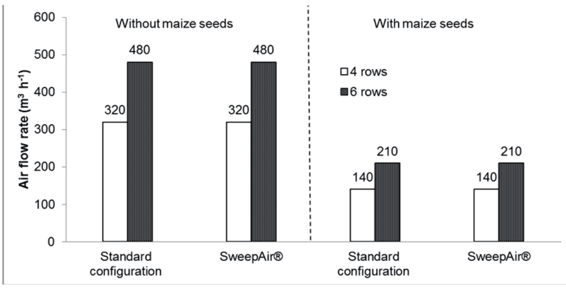


Fig. 2. Air flow rate measured with the machine in standard configuration and equipped with SweepAir® kit.

The vacuum level, measured in the seeding element, registered at the PTO revolution speeds recommended by the manufacturers (540 rev min-1), resulted between 62 and 58 mbar. All values resulted about 30% more than the optimal value (42 mbar) suggested for a good quality of maize seeding (Bragatto, 2008) (Fig. 3).

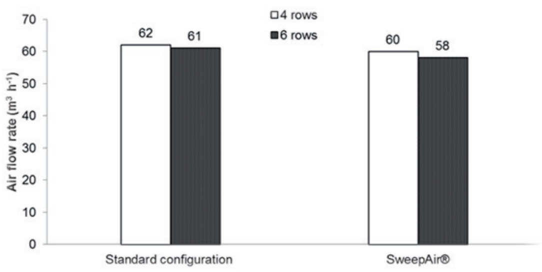


Fig. 3. Vacuum level measured inside the seeding element with the machine in standard configuration and equipped with SweepAir® kit.

4.3 Air velocity under and around the sowing machine

Air velocity measured along the contour of the machine resulted different according to the SweepAir presence. The sowing machine in standard configuration generates an air velocity, measured in correspondence of the edge of the machine, of 2.2 m s^{-1} when it was equipped with four seeding elements and of 1.3 m s^{-1} when it was equipped with six elements. Differently, it was observed that, when the SweepAir® kit was mounted on the seed drill, the resultant air stream was kept within the machine contour equipped only with four seeding elements (Fig. 4).

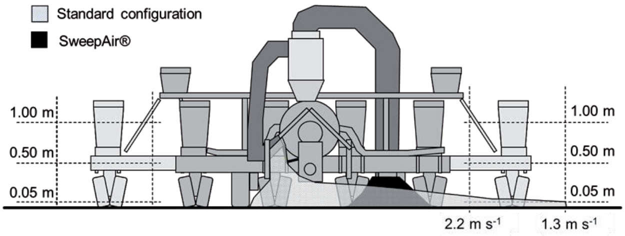


Fig. 4. Characteristics of the air stream generated by the fan of the Seeder in standard configuration and equipped with SweepAir® kit (front view of the machine).

4.4 Footprint of the dust material

Tests carried out using the sowing machine in standard configuration pointed out that the dust blown out by the fan deposited on a surface of about 6 m2 and that most part of it (about 95%) was within the machine footprint when equipped with six seeding elements. In addition, the most of the material was collected on the left side of the machine (Fig. 8-9).

Adopting Sweep Air mounted on the seeder, the dust footprint resulted considerably reduced (more than 98%) and it was always concentrated close the center of the machine (Fig. 5). Furthermore, in real operative conditions this contaminated area does not exist because the material is inserted into the soil.

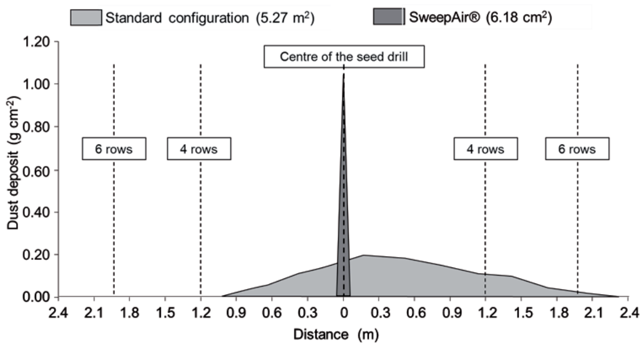
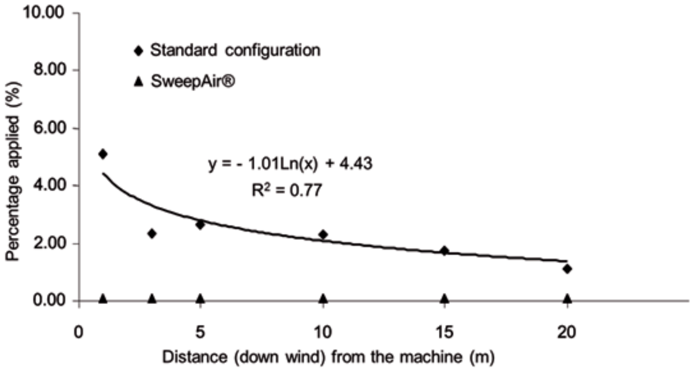


Fig. 5. Amount of dust in footprint area obtained with seed drill in standard configuration and equipped with SweepAir® kit.

4.5 Dust deposit downwind

Results indicated that the amount of dust (tracer) that drifted away from the seeder in standard configuration is 15.6% of the applied quantity. Furthermore, the deposit is strictly related to distance from the machine itself. In fact, values decrease with increasing distance (Fig. 6). Adopting the SweepAir® system any deposit higher than 0.01% (spectrophotometer accuracy) has been found at the different sampling distances from the sowing machine (Fig. 6).



Distance (m)	*1*	*3*	*5*	*10*	*15*	*20*
Standard (SD)	0.08	0.05	0.10	0.06	0.11	0.09
SweepAir® (SD)	-	-	-	-	-	-

Note: SD = Standard Deviation

Fig. 6. Amount of drift material from the seeder in standard configuration and equipped with SweepAir® kit measured at different sampling distances.

5. Conclusions

Trials carried out showed that the SweepAir, differently from devices developed until now, is able to reduce of about 100% the dust dispersion from the fan of pneumatic seeders during sowing operations. Furthermore, it can be applied to all type of maize pneumatic seed drills because it is necessary only to convey the air stream in exit from the seeder fan into the primary pipe of the novel device.

In addition, the use of SweepAir improves general safety conditions of seeding operations because the external surface of the seeder is not contaminated by pesticides.

These results are referred only to the tracer used and they should be confirmed in field using dressed (coated) seeds.

References

Altmann R. (2003). Poncho: a new insecticidal seed treatment for the control of the major maize pests in Europe. Pflanzenschutz-Nachrichten Bayer (English edition) 56, 102-110

Baldessari M., Trona F., Leonardelli E., Angeli G. (2008). Efficacia di acetamiprid e di azadiractina nel contenimento di Dysaphys plantaginea. Proceedings of national conference "Giornate Fitopatologiche 2008"

Balsari P., Manzone M., Marucco P., Tamagnone M. (2013). Evaluation of seeds dressing dust dispersion from maize sowing machines. Crop Protection 51, 19-23.

Basso B., Sartori L., Bertocco M., Cammarano D., Martin C.E., Grace P.R. (2011). Economic and environmental evaluation of site –specific tillage in a maize crop in NE Italy. European Journal of Agronomy 35, 83-92.

Bertocco M., Basso B., Sartori L., Martin E.C. (2008). Evaluating energy efficiency of site-specific tillage in maize in NE Italy. Bioresource Technology 99, 6957-65.

Bragatto G. (2008). Responsible for the engineering sector of the Maschio-Gaspardo manufacturer. Personal Comm.

Chapple A.C., Vrbka L., Friessleben R., Schnier H.F., Cantoni A., Arnold A.C. (2014). A novel technical solution to minimize seed dust during the sowing process of maize using vacuum based equipment: principals and an estimate of efficiency. Aspect of applied Biology 122, International Advances in Pesticide Application, 119-124.

Girolami V., Mazzon L., Squartini A., Mori N., Marzaro M., Di Bernardo A., Greatti M., Giorio C., Tapparo A., (2009). Translocation of neonicotinoid Insecticides From Coated Seeds to Seedling Guttation Drop: A Novel Way Intoxication for Bees. Journal Econ. Entomol. 102, 1808-1815.

Greatti M., Sabatini A.G., Barbatini R., Rossi S., Stravisi A. (2003). Risk of environmental contamination by the active ingredient imidacloprid used for corn seed dressing. Preliminary results. Bulletin of Insectology 56, 69-72.

Greatti M., Barbatini R., Stravisi A., Sabatini A.G., Rossi S. (2006). Presence of the a.i. imidacloprid on vegetation near corn fields sown with Gaucho dressed seeds. Bulletin of Insectology 59, 99-103.

Elbert A., Haas M., Springer B., Thielert W., Nauen R. (2008). Applied aspects of neonicotinoid uses in crop protection. Pesticide Management Science 64(11), 1099-1105.

Nuyttens D., Devarrewaere W., Verboven P., Foquè D. (2013). Pesticide-laden dust emission and drift from treated seeds during seed drilling: a review. Pesticide Management Science 69, 564-575.

Manzone M., Balsari P., Marucco P., Tamagnone M. (2014). Indoor assessment of dust drift effect from different types of pneumatic seed drills. Crop Protection 57, 15-19.

Schnier H.F., Wenig G., Laubert F., Volker S., Schmuck R. (2003). Hey bee safety of imidacloprid corn seed treatment. Bulletin of insectology 56(1), 73-75.

Vrbka L., Friessleben R., Neubauer K., Cantoni A., Chapple A.C. (2014). Bayer Air Washer® and SweepAir®: technological options for mitigation of dust emission from vacuum based maize sowing equipment. Aspect of applied Biology 122, International Advances in Pesticide Application, 113-118