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Comparing two dust drift mitigation strategies to the outcomes of a conventional vacuum based precision drill using in-field validated indoor static tests

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Summary

Although seed treatment is considered as a safe pesticide application method, treated seeds can pose environmental risks when abraded pesticide-laden seed particles are expelled during sowing. Shortly after relating bee killing incidents to neonicotinoid-laden dust particles expelled by vacuum based precision maize drills, the dust drift topic received increasingly more attention from different research groups. CREA-IT and ILVO have both developed devices to mitigate the adverse effects during sowing with vacuum based precision drills.

Both mitigation strategies were coared to a conventional drill and to each other using the validated indoor dust drift setup of CREA-IT and two type of seeds, i.e. seeds coated with thiacloprid and seeds coated with a tracer. In addition, Heubach values and physicochemical properties of the seeds used were measured. Ground and airborne drift deposition results confirmed the important drift reduction capacities of both technologies with drift reduction values ranging from 44% up to 90% compared with the conventional technique with air deflectors. These results confirm that this static method is capable to assess the efficiency of drift reduction devices in a relatively fast and efficient way compared with field trials.

Key words: Dust drift risk, drift mitigation, wind tunnel experiments, electrostatic filter, cyclone

Introduction

Shortly after relating bee killing incidents to neonicotinoid-laden dust particles expelled by vacuum based precision maize drills (Nuyttens *et al.*, 2013), the dust drift topic received increasingly more attention from different research groups. During the MASTER-project, ILVO and KU Leuven assessed the risk of dust drift from seed coating using a combined experimental and modelling approach of which results were shown at the previous conference (Devarrewaere *et al.*, 2016; Foqué *et al.*, 2016).

CREA-IT and ILVO have both developed devices to mitigate the adverse effects during sowing with vacuum based precision drills. In this paper, the outcome of an indoor experiment in which both mitigation strategies were compared to a conventional drill. Apart from the results of these indoor drift experiments, the Heubach values (Zwertvaegher *et al*., 2016) of the used seeds and some physicochemical characteristics of the abraded dust (Foqué *et al*., 2017*a,b*) are shown as well.

Materials and Methods

Seeds

The trials were carried out using two types of maize seeds. First, commercial maize seed (Pioneer Hy-Bred PR32F73 Italia Sementi S.R.L.) dressed with an insecticide (Sonido™, active ingredient(a.i.): thiacloprid) and a fungicide (Celest™, a.i.: fludioxonil and metalaxyl-M). According to the manufacturer, the dose of thiacloprid applied was 1.0 mg seed^{-1}. The seeds were packed in sacks (25,000 seeds sack^{-1}).

In addition, tracer coated seeds were used in order to reduce environmental and operator exposure and to reduce analytical costs. Tracer seeds were developed by Cropsafe (Sint-Truiden, Belgium) in cooperation with ILVO using Co and Mo mineral chelate leaf fertilizers (Chelal®, BMS Micro-Nutrients NV, Rijksweg 32, 2880 BORNEM, Belgium) because of their high stability, recovery efficacy and because multiple tracers can be applied to the same collectors (Foqué *et al*., 2014*a*) and aiming for a medium seed quality in terms of Heubach values (Foqué *et al*., 2014*b*).

Heubach values for both the commercial and the tracer seed batches were determined using the standard Heubach test (ESA STAT, 2011) as described by Zwertvaegher *et al*. (2016).

Pneumatic seed drill and dust drift mitigation technologies

A six-row Gaspardo pneumatic maize seed drill (Gaspardo mod. Magica, Campodarsego, PD, Italy), widely used in Italy, was used for all experiments. The standard setup of this machine (referred to as ‘Con.’) consists a system with four air deflector pipes and was tested before in previous CREA-IT work (Biocca *et al*., 2015, 2016; Pochi *et al*., 2015*a,b*).

The dust drift mitigation technologies developed by CREA-IT and ILVO were both fitted to the same machine. The CREA-IT prototype (referred to as ‘CREA-IT’) uses partial recirculation and filtration of the air by means of an anti-pollen and an electrostatic filter (Biocca *et al*., 2015, 2016). Pochi *et al*. (2015, 2016) compared the CREA-IT prototype to a conventional drill using static indoor simulated wind tunnel tests and field experiments and found promising results in terms of dust drift reduction. The dust drift mitigation technology developed by ILVO (referred to as ‘ILVO’) is based on mounting small cyclones between the fan and each individual drill head as described by Foqué *et al*. (2017*c*).

The three machine configurations (Con., CREA-IT and ILVO) were tested at a sowing rate of 75,000 seeds ha^{-1}, an inter row spacing of 0.75 m, an inter seed spacing of 0.18 m and a vacuum pressure of -45 mbar, using both the commercial (three repetitions for each configuration) as the tracer seeds (two repetitions for each configuration, Co & Mo).

Experimental setup

The static dust drift experiments were performed during summer 2016 at the CREA-IT research facility in a simulated wind tunnel as described by Biocca *et al*. (2015) and shown in Fig. 1. Ground dust deposition was measured at distances of 3.0, 4.5, 9.0, 13.5, 18.0 and 22.5 m from the drill. At each distance, three Petri-dish samplers (Ø 9cm) were placed as shown in Fig. 1, filled with a 50% acetonitrile/water and placed on top of cork squares.

Airborne dust deposition was assessed using two types of samplers: active samplers (Tecora model Bravo) with PTFE diskette filters, operating at 16.5 L min^{-1} were mounted at masts at 2.0 m height, at five downwind positions (3.0, 4.5, 9.0, 13.5 and 18 m). Both for the Petri dishes as for the active samplers, new samplers were used for every test with the commercial seeds. For the tracer seeds, the same samplers were used for both repetitions (Co and Mo).

In addition, two sizes of passive MWAC samplers (Foqué *et al.*, 2014*b*) were attached to the same masts at the same height. The smaller commercially available MWACs (flask volume 125 mL, Eijkelkamp Agrisearch Equipment, www.eijkelkamp.com) and bigger ones designed by the Ghent University (flask volume 549 mL, Department Soil Management, Research Unit Soil Physics). To assure enough dust would be collected, the same MWAC samplers were used for all repetitions made with the same machine configuration and seed type.

For each repetition, 50,000 seeds were used. Based on the thousand grain weight (TGW) this corresponded with about 2.77 kg_{seeds} per hopper for commercial seed and 1.67 kg_{seeds} per hopper for the tracer seeds. The average duration of each static sowing experiment was 16.2 min. After each sowing experiment, the fan generating the wind continued running during one minute before closing all collectors. In this way, all of the dust suspended in the air had the chance to settle down. The wind speeds in the setup were measured with a hand held anemometer at all Petri dish positions at a height of 0.05 m and 2.0 m while the drill was not operating.

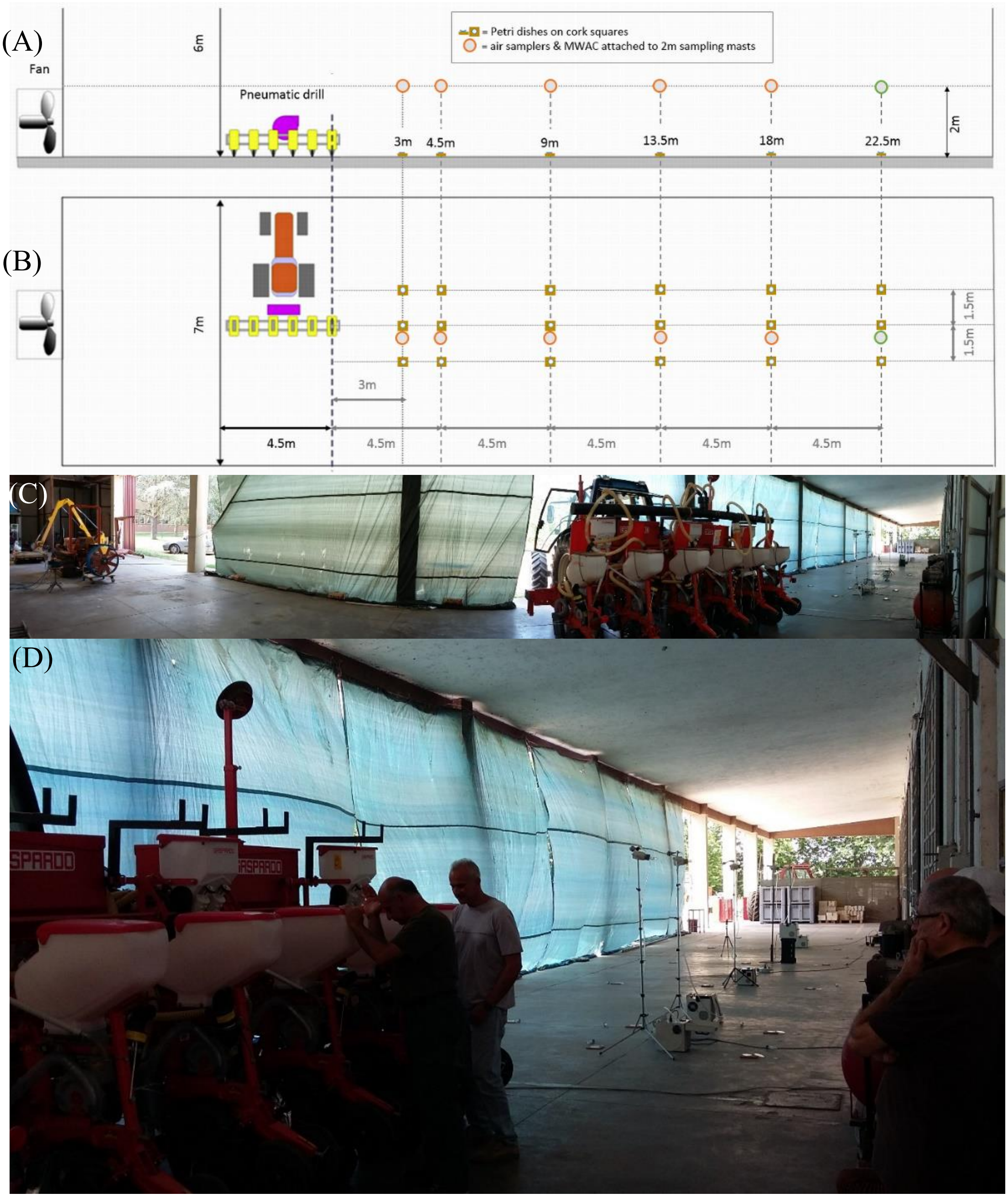

Fig.1. Overview of the static dust drift experiments: schematic (A) side and (B) top view, (C) panoramic picture (D) detailed picture of setup.

Physicochemical dust properties

Apart from the Heubach values, some other important physicochemical characteristics of the abraded dust collected in the cyclones of ILVO's end-of-pipe drift mitigation prototype were measured, i.e. particle size distribution via wet laser diffraction, particle size distribution via sonic sifting and a.i. or tracer content as a function of particle size. Per seed type, the dust collected in the cyclones during all repetitions was used. More information about the techniques and protocols used for the physicochemical characterization can be found in Foqué *et al*. (2017*a,b*). Chemical analysis of the dust, filter and the aqueous solution from the collectors was done as before (a.i. coated seeds: Biocca *et al*. (2016) and Pochi *et al*. (2015*b*); tracer coated seeds: Foqué *et al*. (2014*a*).

Results and Discussion

Heubach tests

The outcome of the Heubach experiments is shown in Table 1. The values of all seed batches are well below the internationally accepted maximum permissible Heubach values ranging from 2.6 to 4.0 g 100 kg_{seeds}^{-1} (Zwertvaegher *et al*., 2016).

Table 1. *Descriptive statistics of the abrasion potential of all seed batches, expressed as g 100 kg_{seeds}^{-1}, g $100{,}000_{seeds}^{-1}$, and g ha^{-1}, and TGW (in g 1000_{seeds}^{-1})*

	Heubach value			TGW
Seed batch	g $100kg_{seeds}^{-1}$	g 100 000_{seeds}^{-1}	g ha^{-1}*	g 1000_{seeds}^{-1}
Commercial seeds	0.37 ± 0.32	0.12 ± 0.32	0.09 ± 0.10	332 ± 2.95
Co tracer coated	1.33 ± 0.35	0.26 ± 0.07	0.24 ± 0.08	199 ± 4.67
Mo tracer coated	1.35 ± 0.25	0.27 ± 0.05	0.27 ± 0.07	202 ± 3.53

* Based on 22 kgseeds ha^{-1} and 75,000 seeds ha^{-1} (Zwertvaegher *et al*., 2016).

Physicochemical properties

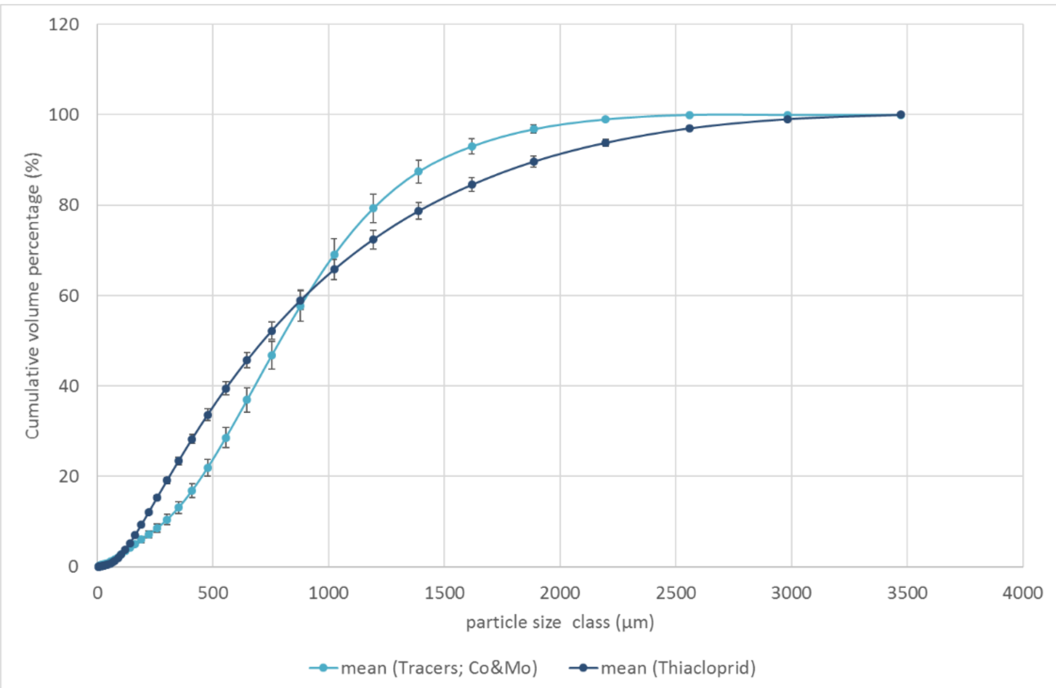

Fig. 2. Particle size distribution of the particles abraded from the commercial and tracer coated seeds (mean ± SE) determined by wet laser diffraction.

Particle size distribution

Fig. 2 shows the cumulative volumetric particle size distribution of the particles abraded from the commercial and tracer coated seeds determined by wet laser diffraction. Although both curves correspond well, a slightly finer particle size distribution was produced by the commercial seeds.

Chemical content

Fig. 3 presents active ingredient dust content (fludioxonil, thiacloprid and metalaxyl-M) for the commercial seeds as a function of particle size. The important absolute differences in a.i. content between the three products, can be explained by the differences in dose rate. For thiacloprid, the typical peak-like curve observed by Foqué *et al*. (2017*b*) is confirmed with highest a.i. content for particle sizes around 100 µm and a decreasing a.i. content for bigger particles. This typical curve was not confirmed for metalaxyl-M and fludioxonil. In case of fludioxonil, highest a.i. content was found for the biggest particles while a.i. content of metalaxyl-M was relatively constant and very low. These differences can probably be explained by the order and the position of the coatings of the three products during the coating process.

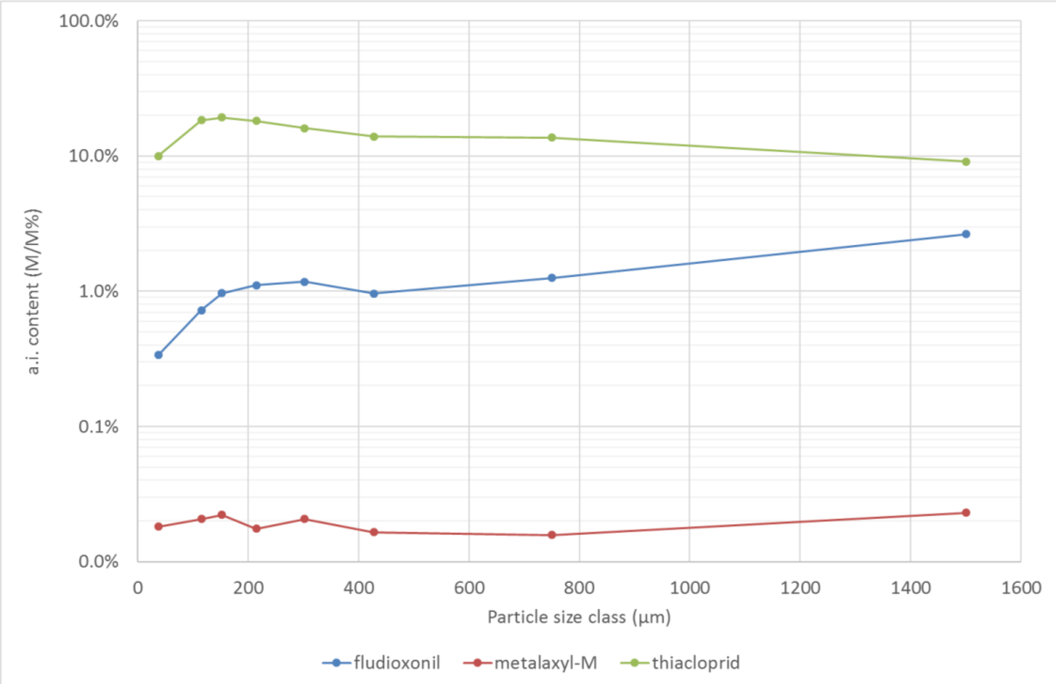

Fig. 3. Active ingredient dust content (M/M%, log-scale) for the commercial seeds as a function of particle size.

Wind velocities

Wind velocities in the measuring setup at heights of 2.0 m and 0.05 m (while the drill was not operating) are shown in Fig. 4. A distinguished wake effect behind the tractor and drill can be seen. Wind velocities range up to 3 m s^{-1}.

Dust drift (reduction) values

Ground dust deposition

Fig. 5 presents average a.i. ground dust deposition values for the three machine configurations with the drill at the beginning of the tests, not all repetitions could be used for futher analysis. Preliminary statistics showed that with the ILVO device the first repetition should be neglected, while for the CREA-IT modification, only one repetition remained. For the latter, the reduction ofthe dataset was further justified by comparing the new data to earlier reported results (Potchi *et al*., 2015*a*). No significant differences were observed between the three repetitions of the conventional drill.

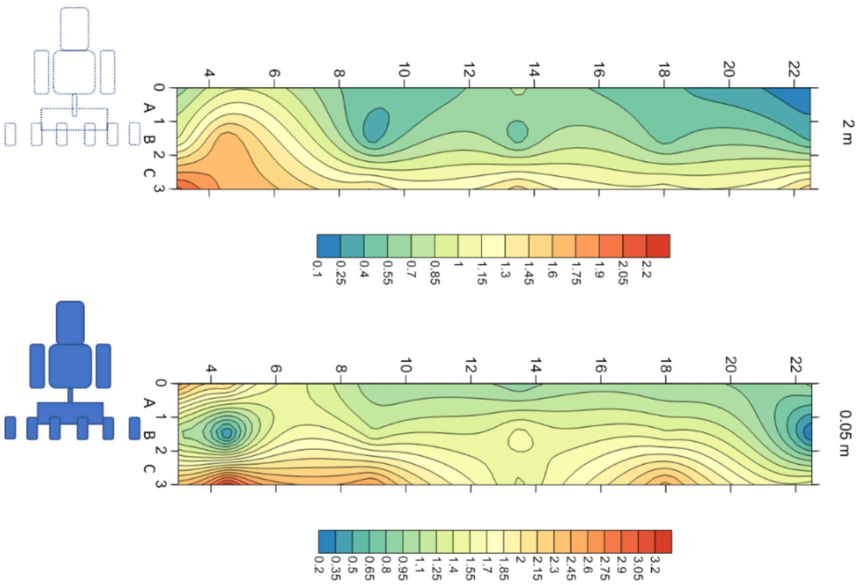

Fig. 4. Fan induced wind speeds (m s^{-1}) in the setup at heights of 2.0 m and 0.05 m while the drill was not operating.

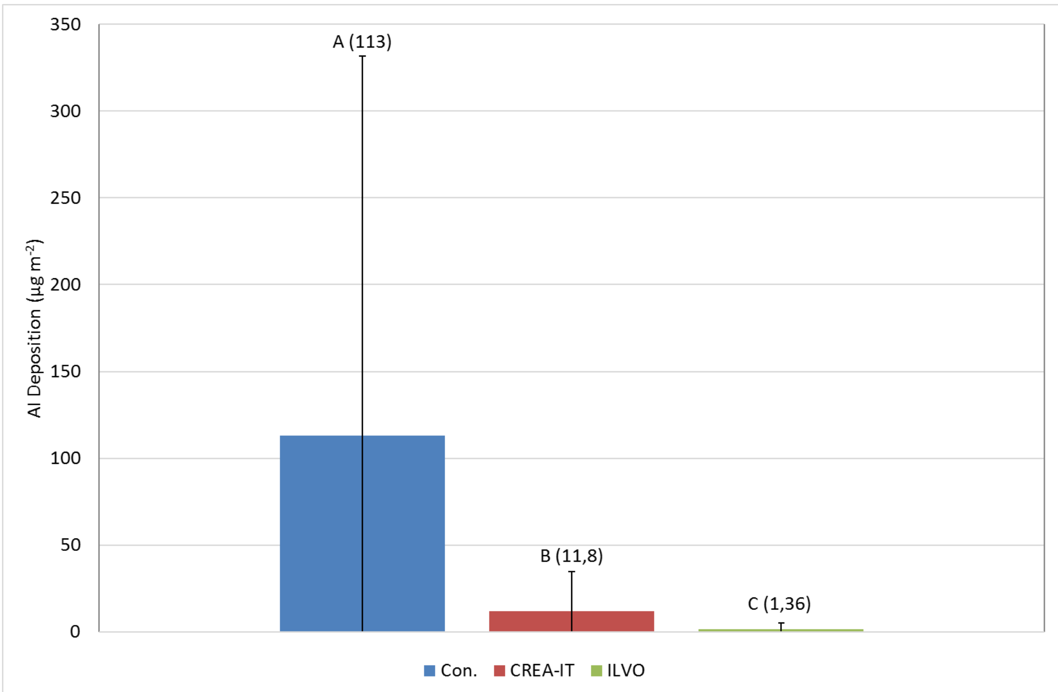

Fig. 5. Effect of machine configuration on a.i. ground dust deposition (mean ± SD). The letter labels show statistically significant differences (P<0.05). Due to some technical problems.

Both drift mitigation technologies significantly reduced the amount of ground dust deposition. Compared with the conventional setup, reduction values of 90% and 99% were found for the CREA-IT and ILVO modification respectively. The amount of ground dust deposition clearly decreased with increasing distances from the drill (results not shown).

Airborne dust deposition

Fig. 6 presents the amount of a.i. captured by the active samplers for the three machine configurations. Both mitigation technologies have a huge mitigating effect on the air suspended dust fraction with reduction values of 83% and 92%, respectively, for CREA-IT and ILVO compared with the conventional set up. Similar results were found based on the amount of a.i. captured by the MWAC with reduction values of 65% and 90%, respectively for CREA-IT and

ILVO. In contrast with ground dust deposition values, airborne dust deposition values were relatively constant for different distances from the drill.

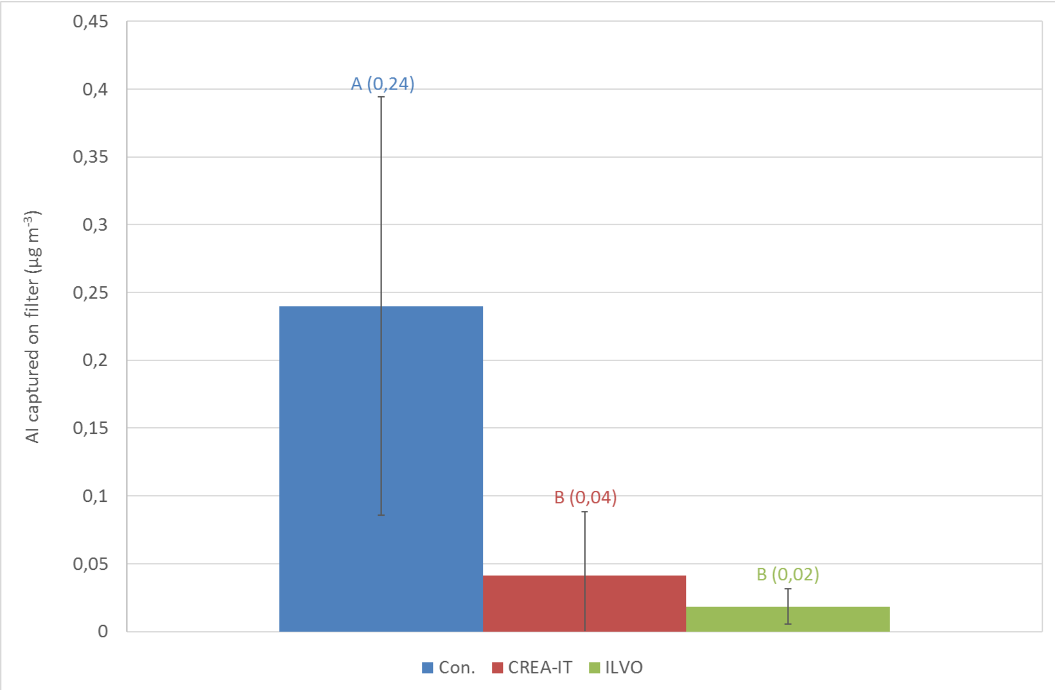

Fig. 6. Effect of machine configuration on the amount of a.i. captured by the active samplers (mean ± SD). The letter labels show statistically significant differences (P<0.05).

Conclusions

Two dust drift mitigation technologies were evaluated and compared with a conventional maize seed drill using using validated static tests in a simulated wind tunnel both with commercial and tracer coated seeds. For both seed types, Heubach values and physicochemical characteristics were determined. In general, Heubach values, particle size distribution and active ingredient content results were in line with what was expected based on previous results. Ground and airborne drift deposition results confirmed the important drift reduction capacities of both technologies. Drift reduction values ranging from 83% up to 99% were found compared with the conventional technique with air deflectors. The CREA-IT prototype uses partial recirculation and filtration of the air by means of an anti-pollen and an electrostatic filter while the ILVO device is based on mounting small cyclones between the fan and each individual drill head. These results confirm that this static method is capable to assess the efficiency of drift reduction devices in a relatively fast and efficient way compared with field trials.

Acknowledgement

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