UAV spreaders for slug pellets Comparison with ground-based spreaders

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Abstract

Unmanned aerial vehicles (UAVs) equipped with spreaders are increasingly used for applying slug pellets. Compared to conventional ground vehicle-mounted-equipment, UAV spreaders can be deployed under wet soil conditions without causing damage to plants and soil. The results of field trials show that the deposition patterns achieved by a commercial UAV spreader are characterized by coefficients of variation of about 30–40 %. For comparison, two standard single- and double-disc spreaders mounted onto ground vehicles were tested according to a similar protocol. They achieved coefficients of variation of 23–40 %. In nearly all tests, the relative amounts of slug pellets collected beyond the chosen working width are above 3 ‰ of the total amount applied.

1 Introduction

Organic and conventional farming often relies on molluscicides, also referred to as slug pellets, to control gastropods. Slug pellet treatments are typically performed with ground vehicles fitted with single or double disc spreaders mounted onto quad bikes or tractors. Such machines, however, may cause soil compaction, especially under very moist conditions in spring or autumn, and crop loss along tramlines. Consequently, there is an increasing interest in unmanned aerial vehicles (UAVs) equipped with spreaders that are suitable for slug pellet treatments, henceforth referred to as “UAV spreaders”. They not only overcome the above-mentioned drawbacks but may also be particularly suitable for spreading slug pellets, as typical application rates range from 5.0–7.0 kg/ha, and hence, the limited payloads of UAV platforms become less of an issue.

The commonly accepted measure of deposition uniformity is the coefficient of variation (CV), which corresponds to the standard deviation of deposit values across a given width divided by the mean of the same deposits, with lower CVs indicating more uniform deposition [1]. While a CV of less than 15 % is mandatory for fertilizer spreaders according to the European Norm 13739 [2, 3], no universally acceptable threshold exists for slug pellet applications. This may be in part due to the lack of standardized testing protocols relating to slug pellet applications. Nonetheless, a CV of 20 % has previously been proposed [4]. In the same publication, the author has reported that five different standard single disc spreaders, which are used in conjunction with ground vehicles in practice, achieved CV values ranging from 20–30 %. We are not aware of any published data on spreading uniformities of UAV-based slug pellet applications.

Tight control over deposition patterns is also important to avoid treatments beyond the field edge. Specifically, no more than 3 ‰ of the applied fertilizer should be thrown beyond the field edge according to EN 13739-2:2012-05 [3]. So far, no such value has been defined for slug pellets.

The present work addresses the slug pellet deposition patterns achieved with a UAV spreader and two ground vehicle-mounted spreaders. Spreading uniformities were quantified as well as the number of pellets outside the chosen working width. Representative spreaders were tested but it was decided not to include specific brand names and other details in this paper.

2 Material and Method

2.1 Application equipment and parameters

Three commercial slug pellet spreaders were tested: a quad bike equipped with a small single disc spreader, a tractor mounted double disc fertilizer spreader and a UAV fitted with a single disc spreader. The three systems were similar in that the mass flow from the spreader tank to the spinning disc was gravity-fed. The quad bike and the tractor were driven at a speed of 2.77 m/s. The UAV spreader flew at a speed of 7.0 m/s and a height of 3.0 m above the ground. The nominal working widths of the spreaders were set to 21.0 m (quad bike, tractor) or 12.0 m (UAV). The nominal application rate was 7.0 kg/ha in all trials.

2.2 Field trials

The lateral distribution of slug pellets and the total spreading widths were assessed according to EN 13739-2: 2012-05 [3]. Trials were performed on a flat meadow. The layout is illustrated in Fig. 1. Applications involved a single straight driving/flight line that started ~10.0 m before and ended ~10.0 m after the detection area, which was covered with non-woven fabric. It contained two rows of collection trays spaced by 7.5 m that covered a width of 20.0-36.0 m such that the complete throwing width was sampled. Both tray rows were oriented perpendicular to the driving/flight line. Each collection tray covered a surface of 0.5 m x 0.5 m and the inside was fitted with grids to prevent slug pellets from bouncing out. Trials involving ground vehicles involved tramlines without trays that were 3.0 m (tractor) or 1.5 m (quad bike) wide. Field trials involved two commonly used slug pellet products. Each test was replicated 4 times. After each application, the number of slug pellets in each collection tray was counted.

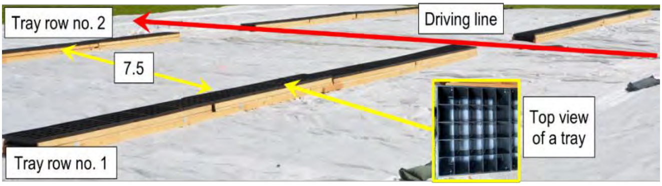

Figure 1: The experimental setup for testing spreaders.

2.3 Data analysis

The data collected in each test run was processed in Excel sheets. For each replicate, the results of the two rows of collection trays were averaged. Subsequently, each averaged distribution was used to simulate a deposition pattern that might result from multiple back-and-forth passes, followed by calculating the CV according to EN 13739-2: 2012-05 [3].

3 Results

In general, all spreaders were characterized by highly variable deposition patterns and precise border spreading was only occasionally achieved.

3.1 Spreading patterns

As shown in Fig. 2, deposition patterns of the UAV spreader were characterized by considerable trial-to-trial variability. CV values at 12 m working width ranged from 30–40 %. It should be noted that pellets were collected over a width of up to 17 m, which corresponds to the total throwing range. Roughly 10 ‰ of the applied pellets were collected beyond either side of the selected working width.

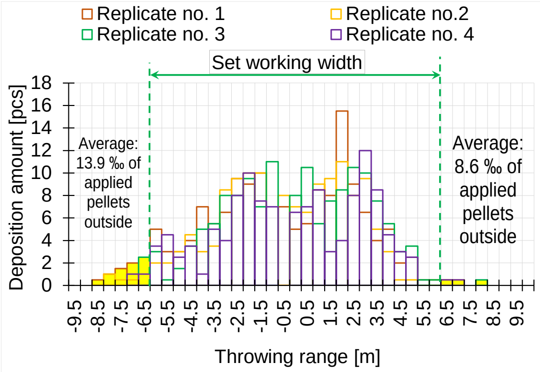

Figure 2: Transversal distributions achieved with the UAV spreader.

As illustrated in Figs. 3 and 4, ground vehicles equipped with spreaders were characterized by a chosen working width of 21 m. CV values were 23–40 %. The relative number of pellets outside the set working width (one single side) was up to 114 ‰ of the applied amount.

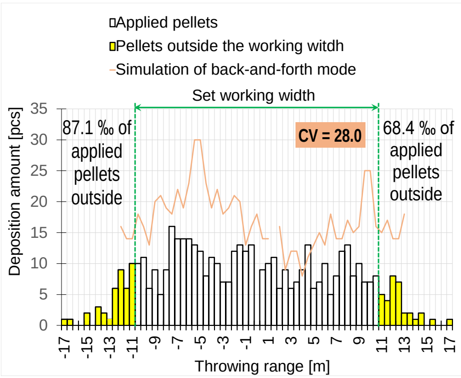

Figure 3: Representative transversal distribution achieved with the double disc spreader (bars) and the calculated distribution relating to a broadcast application (orange line).

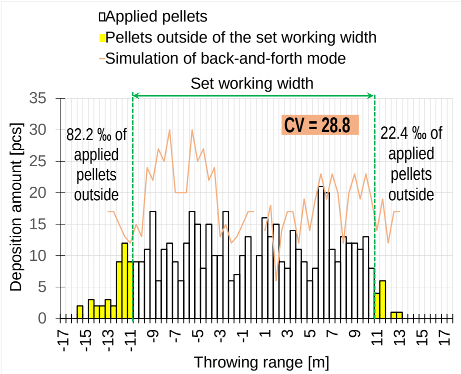

Figure 4: Transversal distribution achieved with the single disc spreader mounted onto a quad bike (bars) and the calculated distribution relating to a broadcast application (orange line).

3.2 Border spreading

The spreader mounted onto the tractor was additionally fitted with a boundary spreading device. A representative spreading pattern is depicted in Fig. 5. The boundary spreading device substantially reduced the number of pellets outside the selected working width (cf. Section 3.1).

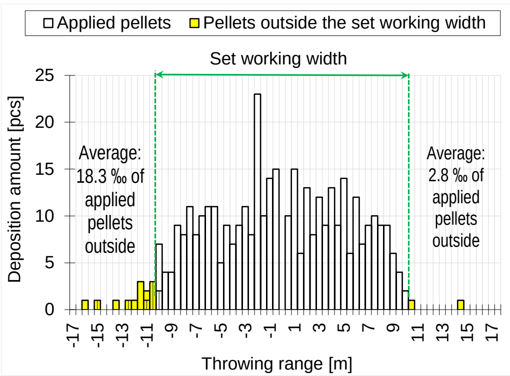

Figure 5: Representative transversal distribution achieved with the double disc spreader equipped with a boarder spreading device mounted onto a tractor (columns).

4 Discussion

The present study demonstrates that the European Norm 13739-2:2012-05 [3], which has originally been conceived for fertilizer spreaders, can be applied for characterizing the deposition patterns of slug pellet spreaders. In field trials that were conducted accordingly, a UAV spreader achieved CV values ranging from 30–40 % while two ground vehicle-mounted spreaders achieved CV values of 23–40 %. These results suggest that the ground vehicle-mounted spreaders may achieve slightly more uniform deposition patterns than the UAV spreader under the test conditions. However, all three machines exceeded the previously proposed threshold of 20 % [4]. The CV values determined for the ground vehicle-mounted spreaders are in good agreement with CV values reported earlier, even though the authors employed a different methodology [4]. The number of pellets found beyond the selected working width was in many cases over 3 ‰ of the total amount applied.

5 Conclusions

Optimizing spreading uniformities and decreasing the number of pellets outside the chosen working width permits to achieve optimal efficacies of slug pellet treatments while minimizing the risks. Several possible directions may be explored in this context:

Calibration: Earlier reports suggest that very low CV values can in fact be achieved upon carefully adjusting the spreader [5]. Calibration routines that are straightforward to implement in agricultural practice would help fully exploit the technical capabilities of spreaders.

Homogeneity of the slug pellets: The importance of pellet weight and dimensions for spreading patterns has been highlighted earlier [6]. It may be possible to optimize the physical homogeneity of slug pellets to improve deposition uniformities achieved in slug pellet treatments.

Adapting the supply system: All spreaders tested here were gravity-fed. An active transport mechanism towards the discs might help ensure an even supply of slug pellets, especially for ground vehicle-mounted spreaders operated on uneven terrain.

Further efforts of spreader and slug pellet manufacturers to improve the deposition uniformities achieved in slug pellet treatments while reducing the amount of pellets deposited beyond the field edge are encouraged.

6 Literaturverzeichnis

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