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Image based techniques for determining spread patterns of centrifugal fertilizer spreaders

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Abstract

Precision fertilization requires new techniques for determining the spread pattern of fertilizer spreaders. Because of the accuracy and non-intrusive nature, techniques based on digital image processing are most promising. Using image processing, dynamics of particles leaving the spreader can be determined. Combined with a ballistic flight model, this allows predicting the landing position of individual fertilizer particles. In a first approach, a two-dimensional imaging technique was used with small field of view (0.33 m on 0.25 m). In the second approach, a larger field of view (1 m on 1 m) was used. To improve the accuracy of previous technique, binocular stereovision was used to determine three-dimensional information.

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1. Introduction

Precision fertilization requires the right amount of fertilizer to be placed at the right moment at the right spot. This

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implies amongst others that the spreader used must be precisely controlled and adjusted, depending on the working conditions, the type of fertilizer and the optimal fertilizer distribution. Although the centrifugal fertilizer spreader is most commonly used in practice, its controllability and adjustability are rather limited. Nowadays, spreader adjustment is often neglected because of the labor intensive and time consuming nature of spread pattern determination (Tissot et al., 2002). High speed image processing is becoming more of interest in agricultural applications (Hijazi et al., 2012; Vulkagaris Minov et al., 2015). Using this technique to determine dynamics of fertilizer particles on the flight, combined with ballistic flight models (Cool et al., 2014), has the potential to overcome most of these problems (Cointault and Vangeyte, 2005). Therefore, the Flemish Institute for Agricultural and Fisheries Research (ILVO) and its partners are exploring and developing accurate and time efficient techniques to measure the spread pattern of centrifugal fertilizer spreaders using image processing. The requirements of the system are:

- The system should be mobile so that it can be used at farm level to test several combinations of machine settings and fertilizer types in a short timeframe;
- It should enable the adjustment of the spreader in such a way that the desired spread pattern is obtained;
- The technique has the potential to allow future development of a low cost and onboard system, allowing for a continuous adjustment and control in the field.

2. Previous developments and approaches

Traditionally, the spread pattern is determined by measuring the fertilizer distribution on the ground. In order to be able to respect the above mentioned requirements under all conditions, however, it was opted for to predict the distribution based on individual particle landing positions. Theoretically, this could be done via the combined simulation of the movements of fertilizer particles on the centrifugal disks on the one hand and the flight of these particles in the air after leaving the disk. As the simulation of the particle behaviours on the disk is much more difficult (time consuming and higher uncertainty on the results) than the simulation of the flight in the air (where particles are further apart and thus hardly interacting), a hybrid approach combining measurements and simulations was proposed: particle diameter, initial velocity, horizontal and vertical outlet angles are measured via processing of images taken just after leaving the disk and used as inputs to a ballistic flight model, which predicts the landing position relative to the disk. Combining the landing positions of all particles leaving the spreader results in the overall spread pattern.

3. Two-dimensional technique

As a first step, a two-dimensional imaging technique was used with a small field of view (0.33m x 0.25m) to measure the horizontal outlet angles and the velocity of the particles at different camera positions at the circumference of the disk. The vertical outlet angle and the mass distribution were measured with a cylindrical collector. The grains flying under the measurement unit were imaged using two different techniques: (1) high speed imaging technique and (2) a newly developed multi-exposure (stroboscopic) imaging technique (see Fig. 1). Overall, the stroboscopic technique and the high speed technique were capable of measuring the outlet angle and the outlet velocity satisfactorily (average relative difference was less than 1% for the horizontal outlet angle and 2% for the horizontal velocity). The values obtained using the image processing techniques were subsequently used for simulation of the ballistic flight and the resulting spread pattern. Comparison of this spread pattern with the spread pattern determined with the traditional technique, revealed relative errors of up to 30%. More details can be found in Vangeyte and Sonck (2007) and Hijazi et al. (2014a).