Journal für Kulturpflanzen, 70 (7). S. 226–228, 2018, ISSN 1867-0911, DOI: 10.1399/JfK.2018.07.03 Verlag Eugen Ulmer KG, Stuttgart

Andreas Herbst[1], Jane A. S. Bonds[2]

A method for determining the central lateral position of a spray swath

Eine Methode zur Bestimmung der lateralen Position eines Spritzschwades

Abstract

An aerial swath offset experiment was conducted to measure the accuracy of two commercial navigational systems for compensation of cross wind influence. The swaths produced in this experiment presented many different deposit patterns. A method was required to determine a position for the differing distributions on the ground. This paper describes a possible solution of this problem. Equivalent to the centre of gravity in mechanics, the use of a Centre of Deposition calculation proved appropriate. The way of calculation is exemplified.

Key words: swath width, centre of deposition, aerial application, deposition profile, offset

Zusammenfassung

Die Genauigkeit zweier Systeme, die bei der Applikation mit Luftfahrzeugen durch Versatz der Flugbahnen den Einfluss des Seitenwindes auf die Verteilung der Spritzflüssigkeit kompensieren sollen, wurde experimentell ermittelt. Dabei wurden sehr unterschiedliche Verteilungsmuster festgestellt, so dass eine geeignete Berechnung der Position des Behandlungsstreifens gefunden werden musste. Zur Beschreibung der Position des Behandlungsstreifens wurde, in Anlehnung an die Berechnung des Schwerpunktes in der Mechanik, der Belagsschwerpunkt ermittelt. Die Berechnung wird im Beitrag beschrieben.

Stichwörter: Behandlungsbreite, Position, Belagsschwerpunkt, Luftfahrzeug, Applikation, Versatz

Introduction

When applying plant protection products using aircrafts, spray drift is one of the most significant environmental hazards. To reduce drift deposit downwind from the field, it is recommended to not release the spray directly on the downwind edge. The flight path near this edge is moved upwind according to the wind conditions (Hoffmann et al., 2010). This can be controlled by navigational systems that calculate swath offsets according to the actual weather data. This calculation is based on the AgDISP model developed by Teske et al. (2003) to predict the distribution of the spray deposit from aerial application.

An experiment was conducted recently which was designed to determine the accuracy of these systems (Bonds et. al, 2018) by measuring the spray deposit across the spray swath using passive collectors. The resulting swaths on the ground were a mixture of histogram shapes, normal, skew and bimodal. With conventional application experiments it is sufficient to describe these distribution patterns or to determine the coefficient of variation from overlapping swaths. But in this special case it was essential to identify a central point to define the spray swath position in order to compare this to the intended position. The following note describes the method chosen for the evaluation of these experimental

Institute
Julius-Kühn Institute, Institute for Application Techniques in Plant Protection, Braunschweig, Germany[1]
Bonds Consulting Group LLC, Panama City Beach, USA[2]

Correspondence
Dr. Andreas Herbst, Julius-Kühn Institute, Institute for Application Techniques in Plant Protection, Messeweg 11/12, 38104 Braunschweig, Germany, e-mail: andreas.herbst@julius-kuehn.de

Accepted
8 June 2018

spray deposit data. The application of this method on experimental data will be shown in the paper mentioned above (Bonds et. al, 2018).

The concept

The aim was to find a single parameter defining the position of the spray swath resulting from the deposit distribution. A similar problem is known from mechanics when the distribution of the mass of a body shall be characterised, for instance in order to describe the point where the resulting gravity force acts. This point is known as the centre of gravity. For the spray swath, the Centre of Distribution CoD is calculated analogue to the centre of gravity of a sheet of constant thickness bounded by the spray deposit curve and the x-axis (base line). In physics, the centre of gravity is the point of this sheet where a force applied would not create any momentum. The mass (or deposit) distribution of that sheet would clearly influence the x-position of the centre of gravity.

This principle was also used to describe the position of an airborne drift bulk above a wind tunnel floor (Herbst, 2001).

The method

Figure 1 shows two examples of aerial spray swaths in terms of measured lateral spray deposit distribution following from a single pass. Both are artificial patterns but similar to some of those found at practical tests. Position × = 0 m is the intended target position of both swaths. Both spray deposit distributions have two peaks. They are identical at positive positions; but at the negative positions the distributions are different: There are the same peak deposits but the position of those peaks are different, they are mirrored at × = −20 m.

Both distributions can be displayed as a combination of rectangles; the total spray deposit V can be determined by calculating the sum of the area of each rectangle:

$$V = \sum_{i=1}^{n} V_i \Delta x \qquad (1)$$

with:

V_i – specific spray deposit at position i
Δx – distance between deposit measuring positions
n – number of measuring values.

The result of this numerical integration is the spray volume related to the distance travelled. A second integration in travel direction gives the total volume sprayed. Comparing with the spray application rate, this value can be used for calculation of the recovery rate from the spray sampling method.

Both example swaths have the same total spray deposit. A simple way to determine the position of the swath is to calculate the cumulative distribution of the spray deposit and to estimate the position of the point of 50% cumulative deposit. This method is illustrated in Figure 2.

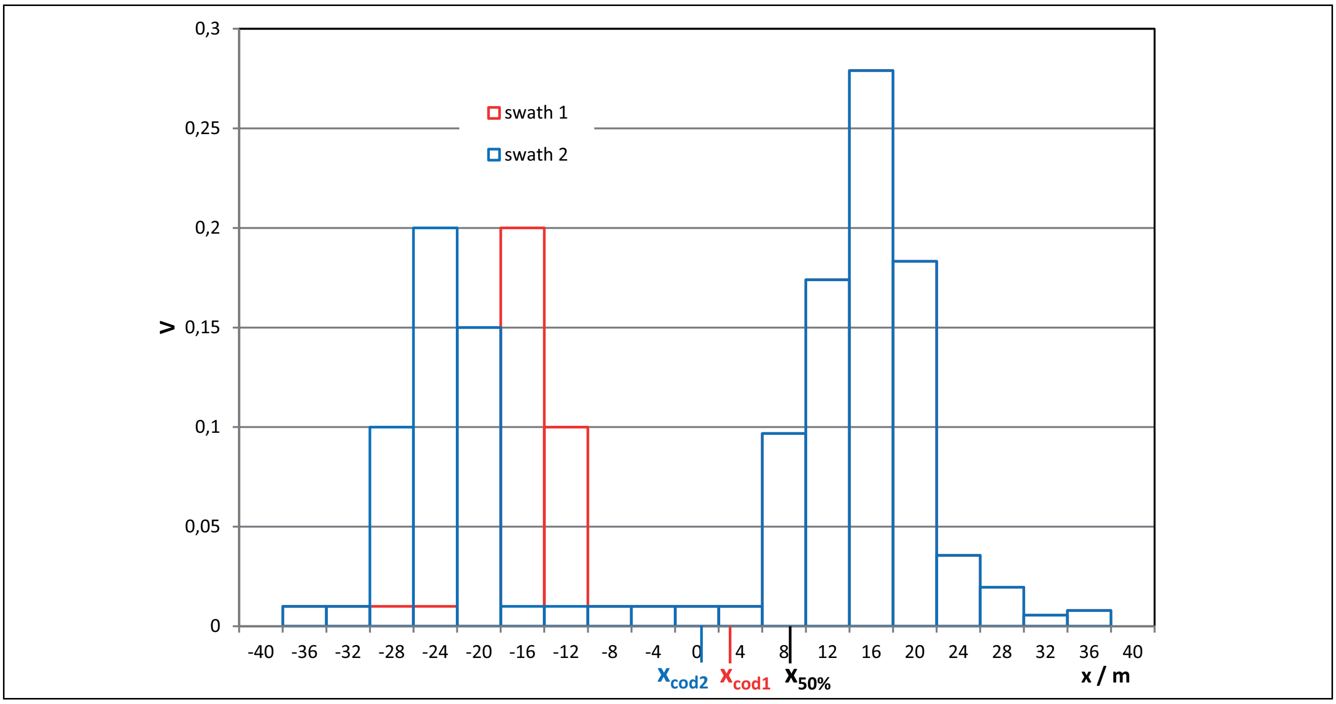

Fig. 1. Lateral spray deposit distributions of two example aerial spray swaths.

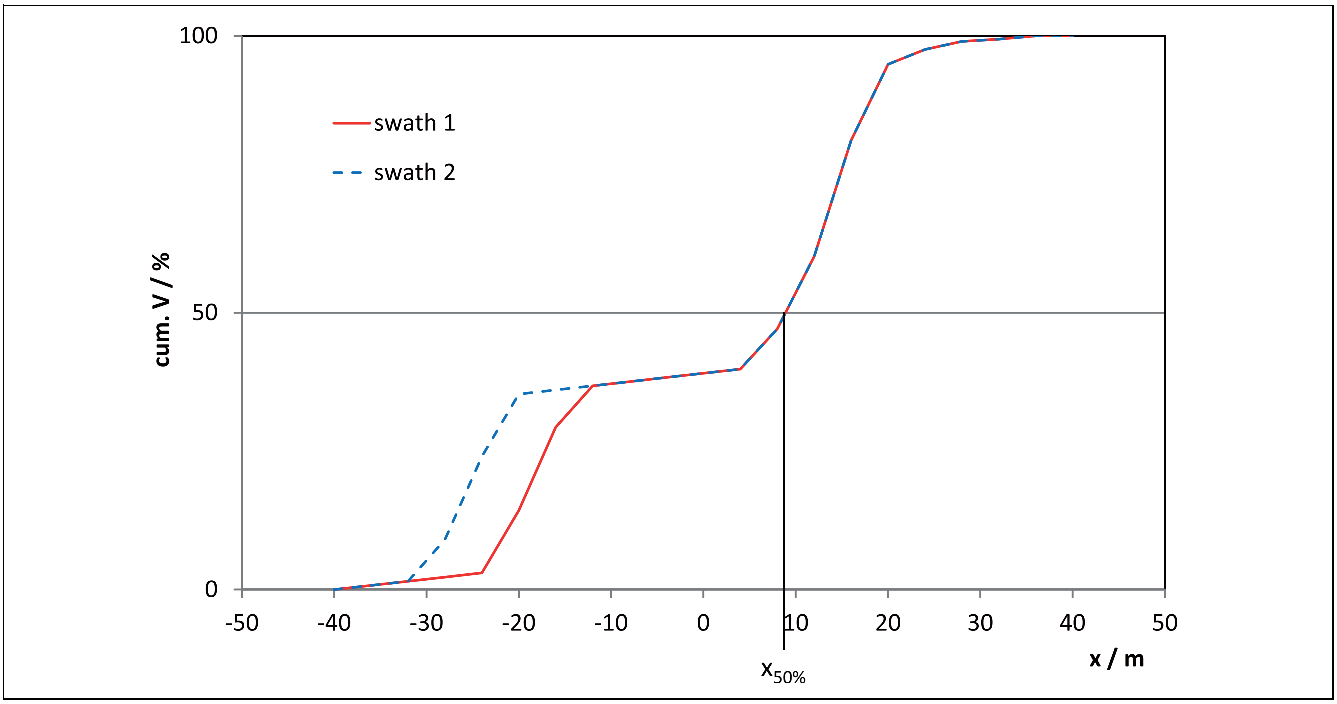

Fig. 2. **Cumulative normalized spray deposit distributions of two example aerial spray swaths.**

But obviously this method is not always appropriate as for both example distributions this point is situated at the same position close to × = 9 m, although the distributions are different.

A more appropriate way of determining the swath position is the calculation of the position *xcod* of the Centre of Deposition (CoD) equivalent to the center of gravity:

$$x_{cod} = \frac{\sum_{i=1}^{n} x_i(V_i \Delta x)}{V} \qquad (2)$$

with:

x_i – i^{th} deposit measurement position

The x-positions of the CoD resulting from this calculation are different for both spray distribution calculation curves. For swath 1 it is x_{cod} = 3.14 m while for swath 2 it is x_{cod} = 0.91 m. For the experiment that posed this question this would mean that swath 2 was closer to the target position. The navigational system provided a more accurate calculated swath offset and predicted a more appropriate flight path.

Conclusions

In case of symmetrical spray deposit distributions, both methods described (Cumulative and CoD) would result in the same x-position of the spray swath. Comparing the unsymmetrical spray deposit curves shown in Fig. 1, it would not be appropriate to state that both swaths are at the same position as it would result from calculating the position of the point of 50% cumulative deposit. The centre of deposit calculated according to equation (2) is an appropriate parameter determining the position of a spray swath, no matter how many peaks the spray deposit curves show.

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