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Critical issues in the evaluation of spraying quality of canon mist blowers: a methodological case study

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Summary

The quantitative evaluation of a boom sprayer is typically achieved upon plants or ground distribution (in a sprayed area) and spray drift (outside sprayed area, downwind) as defined by International Standards. When transposed to mist blowers, protocols & methodologies might appear unadapted or undefined.

This paper introduces experimental feed-back in the assessment of mist blower spraying quality used for crop protection (banana crops) or environmental purposes (mosquito control). The definition of an effective sprayed zone according to a spray distribution pattern is discussed through the comparison of two methodologies. The comparison between several types of sprayers might be critical as spraying conditions may vary (e.g. number of spraying sides). The results on drift values of a mist blower used on banana crop will be discussed as an example.

Key words: Spray application quality, drift, canon mist blowers.

Introduction

Current international standards overarching spraying quality methodologies for boom sprayers concern spray deposition on vegetation (ISO/DIS 24253-Part 1), spray deposits on the ground (ISO/DIS 24253-2) and in-field spray drift (ISO 22866). Transposition of these standards to canon mist blowers faces the fact that the expected target can be located at 30 to 50 m from the mix ejection point. Canon mist blowers are commonly used for mosquito control or banana spraying but also orchard protection (Schultz et al., 2001). Despite the poor quality in deposits distribution, those sprayers allow to spray low and ultra low volumes rates. Very few consideration of drift was found for such sprayers in the recent literature (Ware et al., 1971; Salyani, 1992; Douzals et al., 2010). This paper mainly focuses on the feasibility to use canon mist blowers to spray Aerial Spray Free Buffer Zones (ASFBZ) of 50 m. A first approach consists of a tentative to qualify spray distribution by extrapolation of current standards indicators in terms of application rate distribution with recovery and *ad hoc* coefficients of variation). A second approach highlights spray drift assessment limits by comparing 2 spraying operations. In both cases, the results appeared to be strongly dependant on the methodology.

Materials and Methods

Canons mist blowers.

Six canon mist blowers were tested from 3 manufacturers (Berthoud, Hardi & Martignani). The basic principle of a canon mist blowers is the atomization of a sprayed liquid with the help of the high velocity of the air. In the case of the Hardi sprayer, the atomization is operated by 24 ATR nozzles.

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Typical horizontal spray ranges are found to vary from 25 to 70 m and vertical ranges between 20 to 30 m depending on the air assistance intensity. Manufacturers have developed peculiar adaptations to cope with target configuration.

Due to terrain constraints in natural environment, off-road vehicles/pick-up truck mounting are found for mosquito control. On the other hand banana crop in French West Indies are typically 5 m high which implies that the canon outlet has to be found at 6 m high. However, no standard or current methodology was particularly developed to assess spraying quality of canon mist blowers.

Table 1: Technical characteristics of mist blowers

Sprayer	Spraying principle	Flow rate control	Absorbed Power Av. Wind speed	Max. spray range acc. to the manufacturer
Berthoud Speed Air Fan	Pneumatic Sprayer	Calibrated pellet	18 – 25 kW n. d.	30 m.
Berthoud Sup Air Fan	Pneumatic Sprayer	Calibrated pellet	25 – 30 kW n.m.	30 to 50 m.
Hardi Zenit 400	Air assisted 24 nozzles	24 ATR nozzles	35 kW 50 m/s	30 m.
Martignani Phantom B 819	Pneumatic Sprayer	Variable Restriction	120 kW 80 m/s	50 to 70 m.
Martignani Phantom B 612	Pneumatic Sprayer	Variable Restriction	60 kW n. d.	30 m.
Martignani Phantom B 748 Pickup mounted	Pneumatic Sprayer	Variable Restriction	30 kW 40 m/s	30 m.

n.d. not determined or not available from manufacturer documentation.

Methodology for Off-vegetation tests.

Canon mist blowers were tested according to several protocols adapted either to banana crop spraying or mosquito control. Several flow rates, mixture bases (water or oil), and measurement protocols were tested. For practical reasons, deposits distributions were mostly evaluated without vegetation on a suspended wire at 5m height (banana setting) or at 1 m height from the ground (mosquito control setting). Previous trials with vegetation showed similar order of magnitude in terms of spray ranges, deposits quantities and recovery rate (Vasulik et al., 2009).

Table 2: Off-vegetation deposits measurement protocol.

Banana spraying				
Sprayer	Distance	Sampling	Mix and tracer	Conditions
Berthoud I	60 m. at 5 m high	1 Petri dish every m.	Water + BSF 500 µg/L	Downwind spraying Working height (from ground): 6 m. Working height (from samplers): 1m. Forward speed: 5 km.h ⁻¹
Berthoud II				
Hardi Zenit				
B 612				
B 819				
Martignani B 748	20 m.	1 Petri Dish every 0.5 m up to 10 m then 1 Petri dish every m.	Water + BSF 500 µg/L Oil (Banole™) + CSF 500 µg/L	Downwind spraying Working height (from ground): 1.2 m Working height (from samplers): 1m. Forward speed 5 km.h ⁻¹
Mosquito control (Larvicide)				
Sprayer	Distance	Sampling	Mix and tracer	Conditions
B 748	50 m.	1 Petri Dish every m.	Vectobac™ mix + BSF 1mg/L	Downwind spraying Working height (from ground): 1.8 m Working height (from samplers): 1.5 m. Forward speed 9 km.h ⁻¹

Table 3: Experimental settings

Sprayer	SRM (m)	Mix	Application volume (L.ha ⁻¹)	Recovery rate	Wind speed (m.s ⁻¹)	Temperature (°C)	RH (%)
Hardi-1	30	Water	48.9	31%	1.95	27.9	73
Hardi-3	30	Water	48.1	35%	1.28	27.3	82
Hardi 4	30	Water	78.3	34%	1.14	24.6	89
Hardi 5	30	Water	75.1	35%	1.5	29.8	67
Hardi 6	30	Water	90.4	34%	0.96	27.9	91
Berthoud-1	30	Water	35.1	26%	2.2	29.2	69
Berthoud-2	30	Water	40.7	27%	2.1	28.6	73
Berthoud-3	30	Water	37.5	30%	1.9	27.9	73
M B612-1	30	Water	37.2	26%	2.77	28.6	73
M B612-2	30	Water	47.1	18%	2.93	28.8	71
M B612-3	30	Water	84.9	48%	1.2	27.5	74
M B612-4	30	Water	37.5	43%	0.73	25.6	85
Berthoud-4	40	Water	37.6	36%	0.6	26.4	83
Berthoud-5	40	Water	33.2	40%	0.6	26.5	81
Berthoud-6	40	Water	33.7	51%	1.1	29.3	70
M B819-1	50	Water	50.1	37%	2.35	27.4	77
M B819-2	50	Water	50.9	39%	2.69	28.5	72
M B819-3	50	Water	68.1	28%	1.12	28.8	72
M B819-4	50	Water	62.8	30%	0.86	26.1	85
M B819-5	50	Water	60.5	34%	0.8	28.6	73
M B748 O-1	30	Oil	18.8	31%	0.65	18.3	30
M B748 O-2	30	Oil	16.3	26%	0.55	18.3	30
M B748 O-3	30	Oil	88.8	32%	0.62	18.3	30
M B748 O-4	30	Oil	118.8	43%	0.65	18.3	30
M B748 O-5	30	Oil	133.8	69%	0.68	18.3	30
M B748 W-1	30	Water	28.8	34%	1.32	10.1	75
M B748 W-2	30	Water	21.3	36%	1.35	10.3	75
M B748 W-3	30	Water	90.0	65%	1.31	10.4	75
M B748 W-4	30	Water	110.0	44%	1.33	10.5	75
M B748 W-5	30	Water	165.0	61%	1.35	10.8	75

Data analysis by spectrofluorometry

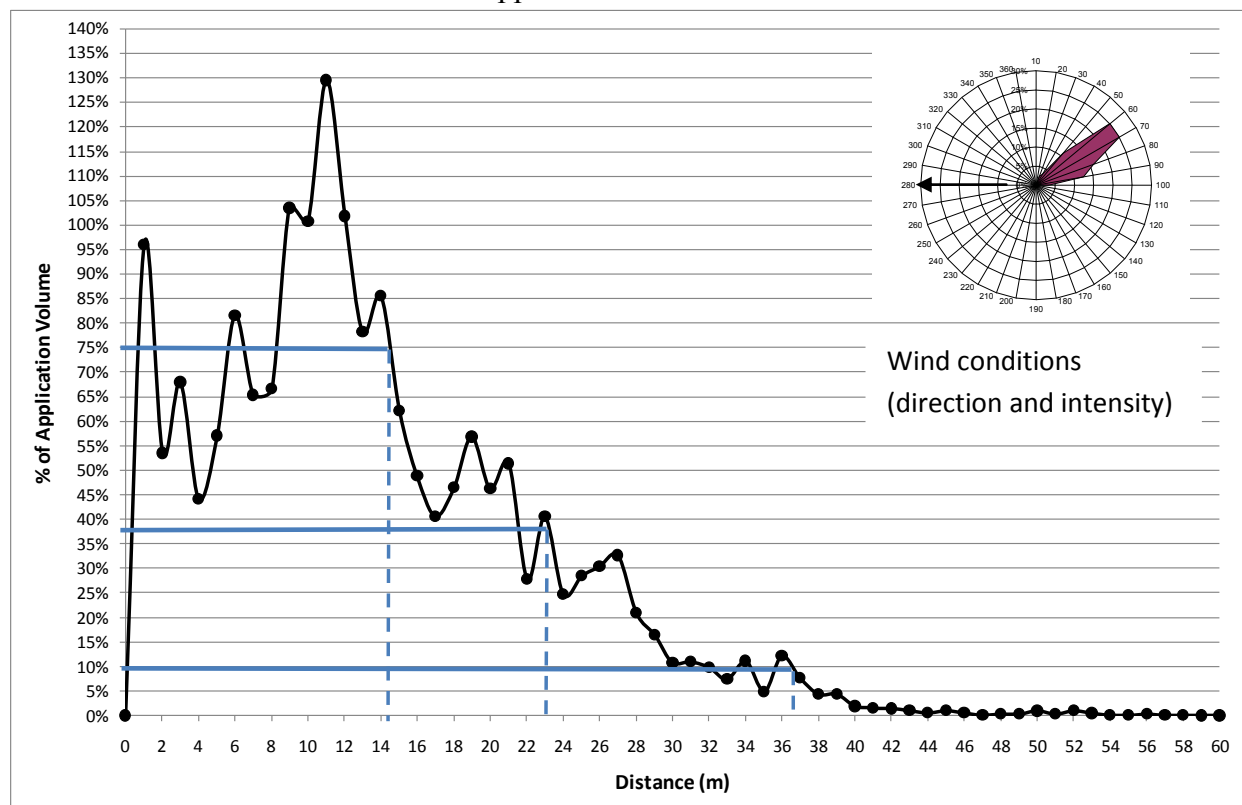
In all cases Petri dishes of 9 mm diameter are washed with 10 ml of *ad hoc* diluents i.e. water or oil depending on mix components. Fluorescence measurements are operated with excitation at 455 nm and fluorescence is observed at 500 nm for both BSF and CSF tracers. Samplers issued from the mix tank are used to draw the calibration curve. Results are directly expressed in terms of Application volume in l.ha^{-1} .

Deposition distribution

Modelling of spray deposits from a canon mist blower was successful (Douzals et al, 2010) with the assumption of a convection-diffusion model. However inputs parameters need to be characterized such as droplet sizes, droplet/air velocity, flow rates and atmospheric conditions. The initial characterization phase represents a laborious work.

This paper focuses on analytical information given by basic measurements in terms of deposits distribution as introduced in fig. 3. Typically, the application volume distribution is heterogeneous along the sprayed distance, mean volume and recoveries are then highly dependant on the calculation method.

Figure 3: Typical distribution curve of a canon mist blower and spray ranges corresponding to 10%-37.5% and 75% of the standard application volume.



The curve introduced in the Fig. 3 corresponds to the median of deposits for 30 trials and considered as a generic deposit curve.

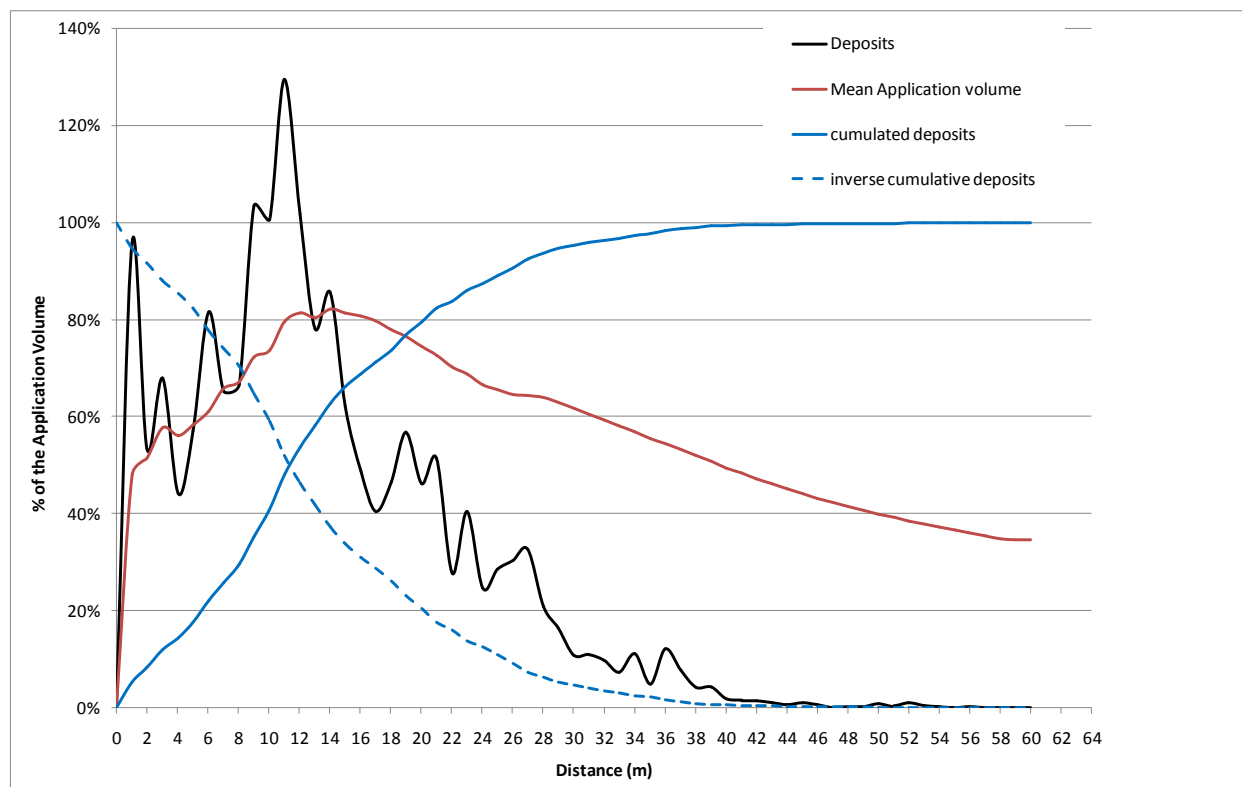
Several distances (Spray Ranges) and Application Volumes were defined:

- Spray Range given by the Manufacturer (SRM)
- Application Volume (AV) is the standard volume obtained with the required flow rate, forward speed and considering the spray range given by the manufacturer.
- Spray Range where 75 % of the AV is found assuming 75 % of the AV is considered as efficient by banana growers (SR 75).
- Spray Range where 37.5 % of the AV is found considering a symmetrical recovery (SR 37.5).

The advantage of the method is the simplicity (no additional calculation is required) but the main inconvenient is that a local peak may artificially shift the recovery distance.

A second analytical method was tested as based on the inverse cumulated values (in %) depending on the distance. The advantage of this method is that the cumulative deposit value at a distance (d) is also depending on the values of previous deposits (d-1, d-2, etc). Previous peaks or pits are then integrated.

Figure 4: Evolution of deposits and inverse cumulative deposit curves as a function of the distance.

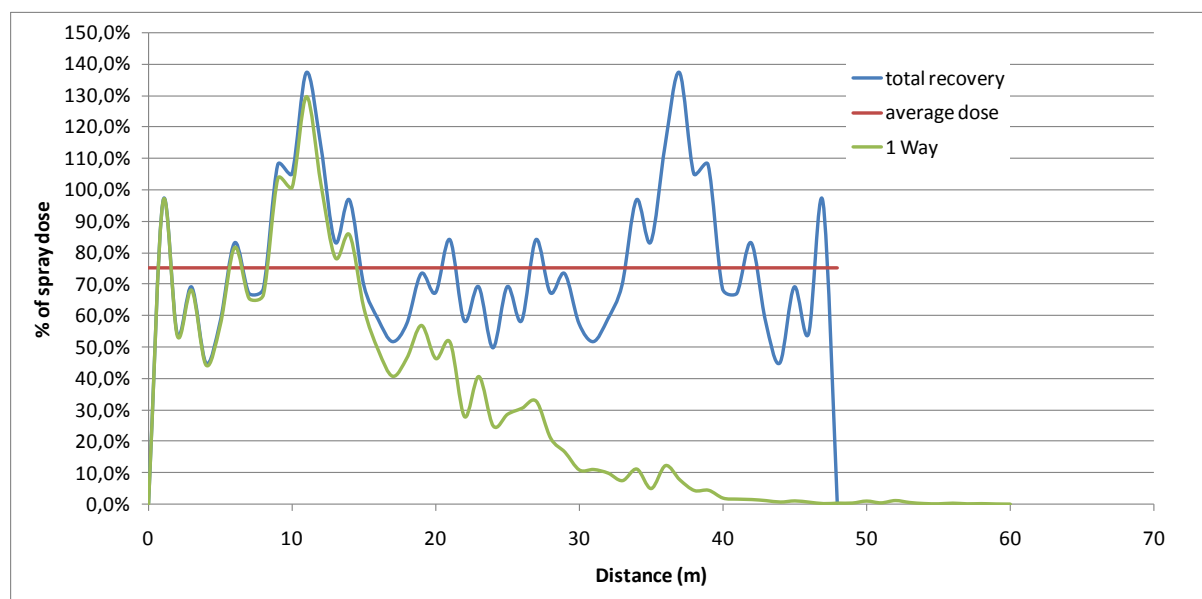


The Mean Application Volume corresponds to the mean value of AV calculated at a given distance (with consideration to previous AV values).

Recovery simulation

Application volumes with recovery were estimated by simulation of symmetrical deposits without wind. In this case the optimum is found when the applied volume reaches 75% of the standard AV compared with data from raw deposits for 37.5% of SD (Fig. 5).

Fig 5: Total deposits with return passage and Mean Application Volume.



For each sprayer, the optimum spray range was determined so as the mean application volume reaches 75% of the SD.

Drift measurements protocol.

The application of ISO 22866 standard to canon mist blowers induces several questions. Indeed most of canons spray only one side. The orientation of the canon towards wind direction is then crucial. In all cases drift measurements are realized according to ISO 22866 Standard with lines of 20 Petri dishes located at 5-10-20-30-50 m and 100 m downwind and parallel to the field edge. Petri dishes are placed every 2 m.

Two sprayers were compared for both drift and vegetation deposits. The 1 side sprayer was oriented against wind, spraying from the field edge, and the 2 side sprayer could spray from inside the banana field. In order to make a comparison possible between those sprayers, several hypotheses were made. First, the influence of the 2 side sprayer was considered on drift was assumed to be equivalent to one swath 22 m wide (2 x 11 m) with consideration to the lateral wind. Second, drift percentages were calculated either on an Application Volume basis or on a flow rate basis. The quantity of deposits on either vegetation or drift zones were then expressed in % of the respective reference.

Meteorological measurements.

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Temperature, relative humidity, wind velocity and wind direction are measured at 6 m high and recorded with a frequency of 3 Hz. ISO 22866 standard defines acceptable wind conditions for drift measurements that was also used to validate spray deposits measurements.

Results

Spraying quality of canon mist blowers

30 trials with different sprayers and working conditions (sprayer, flow rate and mix) were analyzed. Deposits and cumulative methods were tested in terms of the prediction of the recovery distance aiming 75% of the standard Application Volume. Results are introduced on Table 4.

Table 4: Prediction of spray ranges for 30 Canon Mist Blowers from a (single) measurement curve and with recovery leading to 75 % of the standard AV.

Sprayer	SRM (m)	Recovery rate (%)	Data from a single deposition curve				Data from recovery curve (simulated)			
			SR 37.5%		SR 75% estimated from SR 37.5%		deposits		cumulative	
			deposits	cumulative	deposits	Cumulative	SR 75%	CoV	SR 75%	CoV
hardi-1	30.0	30.7%	28	18	56	36	47	36.1%	47	20.4%
hardi-3	30.0	35.4%	28	17	56	34	56	35.3%	43	20.1%
hardi 4	30.0	33.6%	20	10	40	20	54	69.2%	25	18.8%
hardi 5	30.0	34.6%	26	10	52	20	55	51.0%	28	17.4%
hardi 6	30.0	34.4%	29	13	58	26	55	55.5%	36	24.5%
Berthoud-1	30.0	26.2%	20	9	40	18	41	62.9%	24	16.9%
Berthoud-2	30.0	26.5%	29	19	58	38	39	40.5%	43	14.1%
Berthoud-3	30.0	30.2%	29	17	58	34	46	50.2%	40	16.2%
Berthoud-4	30.0	25.7%	22	14	44	28	41	47.2%	32	14.2%
Berthoud-5	30.0	18.3%	24	7	48	14	28	58.8%	20	18.3%
Berthoud-6	30.0	48.4%	28	16	56	32	od		42	22.8%
B 819-1	40.0	43.0%	24	16	48	32	od		43	25.8%
B 819-2	40.0	35.5%	24	24	48	48	54	73.8%	od	
B 819-3	40.0	40.4%	16	13	32	26	od		36	23.8%
B 819-4	50.0	51.2%	33	14	66	28	od		42	27.0%
B 819-5	50.0	36.9%	27	21	54	42	58	37.3%	49	16.9%
B 612-1	50.0	39.3%	31	10	62	20	od		30	30.1%
B 612-2	50.0	28.3%	17	11	34	22	44	65.6%	32	31.4%
B 612-3	50.0	29.6%	22	10	44	20	47	47.9%	30	20.8%
B 612-4	30.0	33.9%	29	9	58	18	54	78.6%	25	23.1%
H18.75C	30.0	30.5%	11	14	22	28	ud		39	35.1%
H16.25 UB	30.0	25.7%	8.5	14	17	28	ud		39	30.8%
H88.75	30.0	31.9%	10	15	20	30	ud		40	27.9%
H118.75	30.0	43.1%	14	14	28	28	23	43.3%	39	28.2%
H133.75	30.0	69.2%	12	13	24	26	39	54.6%	36	35.0%
E28.75 UB	30.0	33.8%	9	14	18	28	ud		37	30.4%
E21.25C	30.0	35.8%	12.5	14	25	28	ud		37	27.2%
E90	30.0	65.3%	15	15	30	30	33	72.9%	39	35.1%
E110	30.0	44.3%	13	15	26	30	22	39.7%	41	34.5%
E165	30.0	61.1%	11	13	22	26	35	32.9%	41	35.6%

od : overdose (the average AV is always over 75% whatever the recovery distance;

ud : underdose (the average AV is always below 75% whatever the recovery distance)

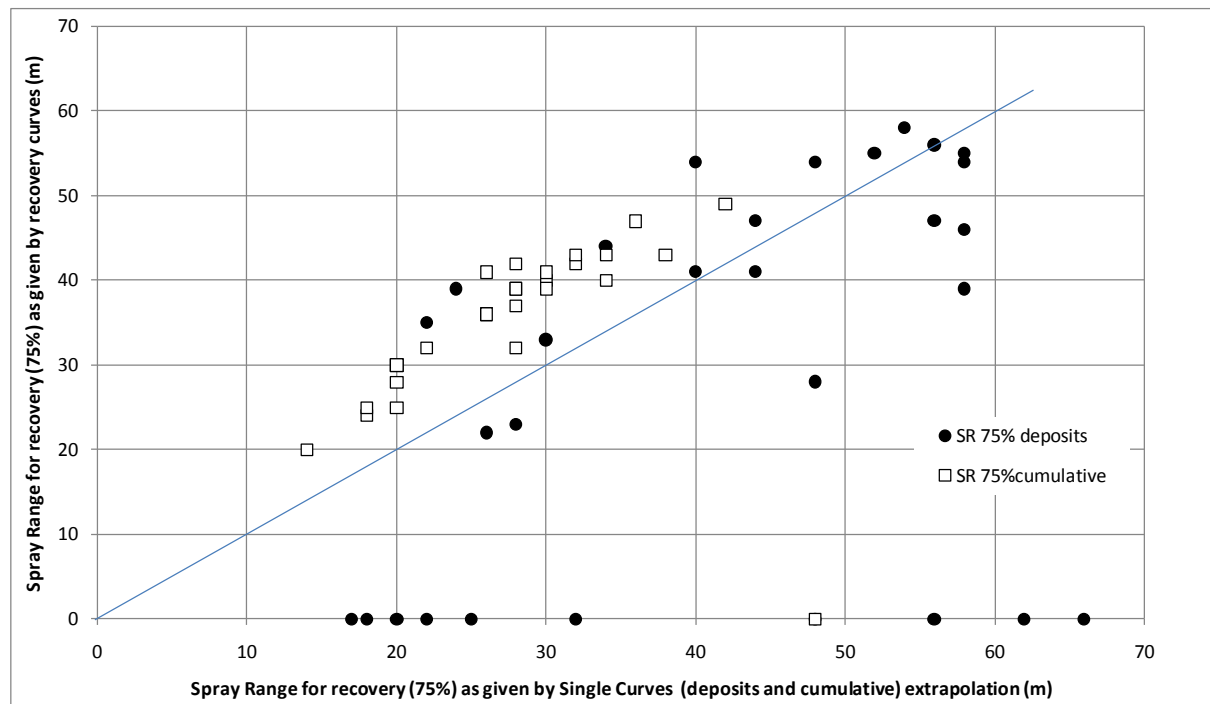
It appears on Table 4 that the cumulative distance generally lowered the recovery distance compared to the deposit method. This result sounds logical as cumulative method integrates all variations of the deposition curve (peaks and pits).

On the other hand, CoV calculated for both simulations showed logically lower values for the cumulative method. Indeed, compared to the deposit method, data are already ranked by cumulative order. Finally, extrapolations of the spray range (75% SD) from single curves data are relatively consistent with the result of the recovery simulation.

Recovery distances cannot be defined when the addition of the single and recovery curves involve AV values greater than 75% of the standard AV (overdose) or when it is not possible to reach 75 % of standard AV (under dose).

Prediction quality for both methods is introduced in Fig. 6.

Figure 6: Prediction of recovery distance depending on the method.



Remark: data found among the X-axis ($y = 0$) correspond to under- or over-dose cases.

As a partial conclusion, the choice of the evaluation objectives and methods may involve different levels of data analysis as well as practical consequences. Both methods lead to coherent definition of the recovery distance with or without the help of the simulator. The method based on raw deposits allows greater recovery distances but with more heterogeneous distribution of the spray mix. On the other hand, a method based on cumulative data takes into account the heterogeneity of the deposition distribution. In this last case, recovery distances are generally lower but distributions with recovery are more homogeneous.

The choice of a strategy is mainly related to agronomic issues depending on the level of over- or under- doses still acceptable.

Canon mist blowers used on banana crop were also tested in order to qualify drift as aerial applications of fungicides and or mineral oil involve a spray free buffer zone of 50m. As the Hardi Zenit 400 was able to spray a low volume mix of 15 l.ha⁻¹, this sprayer was used for drift measurements. With respect to the 22866 Standard and as the drift area was located downwind, the spraying was directed opposite down wind (against wind). This critical situation is however realistic. The recovery rate on vegetation was quite low and represented 4.8% of the expected application volume.

Table 5: Drift values for 5 replicates opposite down wind spraying.

	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Standard AV (l.ha ⁻¹)	15	15	15	15	15
Wind speed (m.s ⁻¹)	2.0	2.2	2.2	2.5	2.5
Wind direction (°)	109	117	109	113	113
Temperature (°C)	26	27	26	26	26
RH (%)	71	71	71	71	70
Recovery on drift area (%)	32.6%	24.0%	36.6%	20.6%	44.0%
Line	Average drift values				
5 m	44.7%	30.6%	42.3%	25.8%	60.4%
10 m	29.8%	19.2%	36.5%	14.5%	35.3%
20 m	17.6%	20.4%	21.8%	14.4%	24.7%
30 m	12.0%	16.6%	13.7%	14.4%	15.2%
50 m	10.7%	2.3%	6.9%	4.5%	5.3%
90 m	0.5%	0.5%	0.5%	0.6%	0.6%

As expected, drift values close to crop field edge are relatively high. In addition to worse wind direction, Crop height of 5 m and mix content (Banole® Oil) may amplify the phenomenon.

Figure 7: Drift values of a canon mist blower 1 side spraying against wind.

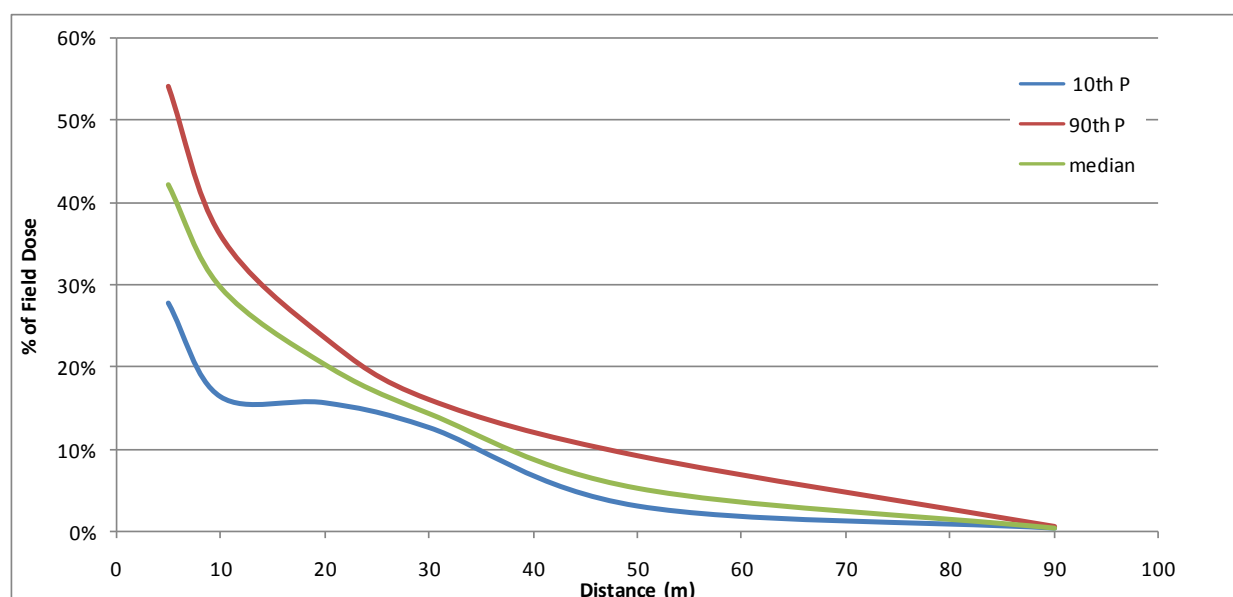


Fig. 7 shows a higher variability of deposits for the lines 5 and 10 m but no specific gradient was found on raw data.

According to hypotheses discussed in Materials and Methods, a global mass balance was estimated for 1 side and 2 side sprayers on a basis of application volume or flow rate.

Table 6: Mass balances of two spraying applications on banana crop.

Reference	Compartment	canon 1 side spraying against wind	canon 2 side spraying
Spray Range considered		30 m	2 * 11 m
Effective Spray Range		11 m	22 m
AV based on SRM	Drift	32%	12%
	Vegetation	5%	62%
	Losses	63%	26%
Flow rate based on effective Spray Range	Drift	14%	12%
	Vegetation	2%	36%
	Losses	84%	52%

Conclusion

The objective of this work was to assess spraying quality of canon mist blowers as potential technique to spray upon buffer zones of aerial treatments. Spray distribution was evaluated through raw deposits or cumulative of deposits. The results showed differences in terms of distance for recovery and coefficients of variation of the distribution patterns. Drift measurements of a canon mist blower spraying against wind was compared with a prototype of 2 sides canon inside the vegetation. A mass balance was calculated in reference to either application volume or flow rate with adjustment of the spray range. Depending on the method, the impact of drift may vary significantly for the 1 side sprayer but also from one sprayer to the other.

References

- Douzals J P, Cotteux E and Sinfort C 2010**, Spraying quality assessment of a mist blower used on banana crops., *Proceedings of AgEng 2010 Conference*, Clermont-Ferrand, France.
doi:hal.archives-ouvertes.fr:hal-00572484
- Vaculik A and Polveche V, 2009** Evaluation of Spraying Quality of a canon mist blower on banana crops, Cemagref - UGPBAN Test report, 70 p.
- Salyani M, Cromwell R P 1992**, Spray Drift From Ground and Aerial Applications, *Transactions of the ASABE*, **35**(4): 1113-1120.
- Schulz R, Peall S K C, Dabrowski J M, and Reinecke A J 2001.**, Spray Deposition of Two Insecticides into Surface Waters in a South African Orchard Area., *Journal of Environmental Quality*, **30**:814–822 (2001).
- Ware G W, Apple E J, Cahill W P, Gerhardt P D, Frost K R 1969.**, Pesticide Drift. II. Mist-Blower vs. Aerial Application of Sprays, *Journal of Economic Entomology*, **62**(4): 844-846.