Research on spray nozzles from the Agrotop TDXL series for drift reduction classification

TDXL 80-015, TDXL 80-02 and TDXL-D 110-02

H.J. Holterman, D.C. de Hoog

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In this study, the nozzle types Agrotop TDXL 80-015, TDXL 80-02 and TDXL-D 110-02 were investigated to classify their drift reduction potential for downward spray applications (at 2, 3 and 3 bar spraying pressure, respectively). The uniformity of the spray distribution was tested on a patternator for the appropriate nozzle height (default height 0.50 m; for the 80-degree nozzles lowered to 0.30 m). For all three nozzle types the resulting coefficient of variation (CV) was less than 10%. Droplet size measurements were done using a PDPA system and the resulting droplet size spectra and droplet velocities were used in the IDEFICS spray drift model. Spray drift deposits on a standardized ditch were computed, as well as the corresponding drift reductions compared to the reference situation. According to the current classification system for drift reducing nozzles, the drift reduction capability of all nozzle types must be evaluated at nozzle height 0.50 m above the crop. At this nozzle height and a nozzle spacing of 0.50 m, nozzle type TDXL-D 110-02 could be classified as 75% drift-reducing (DRD75) at liquid pressure of 3 bar. At a nozzle spacing of 0.25 m, the nozzle types TDXL 80-015 and TDXL 80-02 could also be classified as DRD75, at a nozzle pressure of 2 and 3 bar, respectively. Therefore, these 80-degree nozzle types are eligible to be used as DRD75 nozzles at the given liquid pressures in the drift-reducing technique (DRT) of 'lowered sprayer boom'.

Keywords: drop size distribution, spray drift, drift reducing nozzles, classification

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Preface

This study on the drift-reducing properties of spray nozzles for arable crops was commissioned by Agrotop GmbH, Germany. The study was supervised by Mr. L. Wachter (Agrotop GmbH).

Summary

In this study, the nozzle types Agrotop TDXL 80-015, TDXL 80-02 and TDXL-D 110-02 were investigated to classify their drift reduction potential for downward spray applications (at 2, 3 and 3 bar spraying pressure, respectively). The uniformity of the spray distribution below a sprayer boom was tested on a patternator for the appropriate nozzle height (default height 0.50 m; for the 80-degree nozzles lowered to 0.30 m). For all three nozzle types the resulting coefficient of variation (CV) was less than 10%. Measurements of droplet sizes and velocities were done using a PDPA system; the results of these measurements were used in the IDEFICS spray drift model. Spray drift deposits on a standardized ditch were computed, from which the drift reductions compared to the reference situation were derived. According to the current classification system for drift reducing nozzles, their drift reducing capabilities must be tested at a nozzle height of 0.50 m above the crop canopy. At this nozzle height and a nozzle spacing of 0.50 m, nozzle type TDXL-D 110-02 could be classified as DRD75 at liquid pressure of 3 bar. At a nozzle spacing of 0.25 m, the nozzle types TDXL 80-015 and TDXL 80-02 could be classified as DRD75, at a nozzle pressure of 2 and 3 bar, respectively. Therefore, these 80-degree nozzle types (at the tested liquid pressures) are eligible to be used as DRD75 nozzles in the drift-reducing technique (DRT) of ‘lowered sprayer boom’.

1 Introduction

The Environmental Activities Decree (MinI&W, 2022) prescribes that when a field crop is sprayed with a boom sprayer, the application technique for the entire field must be at least a 75% drift-reducing technique (DRT75). For example, a standard sprayer equipped with 75% drift-reducing nozzles (DRD75) would suffice. The requirements that must be met regarding the drop size distributions of nozzles in order to be regarded as low-drift are described in two documents: (a) "Beoordelingssystematiek emissiereducerende maatregelen open teelt" (assessment system for emission-reducing measures for field crops; TCT, 2017) and (b) "Measurement protocol to determine drift reduction of nozzles for downward-directed and upward/sideways-directed spraying - version 2 November 2021" (MinI&W, 2021; hereinafter simply referred to as 'Measurement Protocol'). The Measurement Protocol also specifies the measurement method to be used in order to apply for certification of a drift reducing nozzle type (i.e. to get a registration on the Dutch DRD list; TCT, 2022a). Drift-reduced nozzles can vary considerably in actual drift reduction. The 'Technische Commissie Techniekbeoordeling' (Technical Committee for Assessment of Techniques; TCT, 2022a) classifies nozzle-pressure combinations into drift reduction classes (DRD50, DRD75, DRD90, DRD95) for use in the various drift-reducing techniques (DRT; TCT, 2022b) and to determine the crop-free zone for intensively sprayed crops. Regarding nozzle types with 80-90 degree top angles, that are intended for use with lowered sprayer boom, the Measurement Protocol requires that the drift reducing capabilities of these nozzles must be tested at nozzle height of 0.50 m, yet the distance between nozzles at the sprayer boom can be 0.25 m.

This study includes three nozzle types from the Agrotop TDXL series, namely TDXL 80-015, TDXL 80-02 and TDXL-D 110-02. The project involves flow rate measurements of individual nozzles, measurement of evenness of liquid distribution on a patternator, drop size measurements and spray drift simulations to determine drift reduction capabilities. The measurement of liquid distribution on a patternator was carried out for relevant combinations of nozzle height and nozzle spacing (ISO5682-1, 2014; ISO5682-2; 2017). According to ISO 16122-2 (2015) the coefficient of variation (CV) of such a distribution should be less than 10%, which is adopted by the Measurement Protocol (MinI&W, 2021). Droplet size measurements were made for nozzle-pressure combinations as requested by the client. The resulting droplet size spectra were used in calculations with the IDEFICS spray drift model (Holterman et al., 1997) to determine the drift deposits onto the water surface of a standardized ditch, for all tested situations with a CV from the patternator measurements less than 10%. Drift deposits from the tested nozzle types are compared to those for a situation with reference nozzles, from which drift reductions can be computed. Finally, for the examined nozzle-pressure combinations the eligible classification into drift reduction classes 75, 90 and 95% is indicated, analogous to the method described by Porskamp et al. (1999), ISO22369 (2006) and the Measurement Protocol (MinI&W, 2021).

2 Methods

For the nozzle types Agrotop TDXL 80-015, TDXL 80-02 and TDXL-D 110-02 (Figure 1), several measurements were carried out subsequently: flow rate measurements of individual nozzles, measurement of evenness of liquid distribution on a patternator, drop size measurements. Finally, spray drift simulations were carried out to determine drift reduction capabilities of the nozzle-pressure combinations. Table 1 shows the nozzle types and pressures in the test, together with their potential use. For instance, nozzle types with a top angle of 80-90 degree (such as the TDXL 80's in this study) are intended for use at lowered sprayer boom, i.e. nozzle height is 0.30m and distance between nozzles is 0.25 m. According to the Measurement protocol their drift-reducing capabilities should be tested The TDX 110-02 is to be used in a standard application (0.50 m nozzle height and 0.50 m nozzle distance).

Table 1 *Nozzle types and pressures in this study.*

No.	Nozzle type	Liquid pressure [bar]	Nozzle height above crop [m]	Nozzle distance along sprayer boom [m]
1	TDXL 80-015	2	0.30	0.25
2	TDXL 80-02	3	0.30	0.25
3	TDXL-D 110-02	3	0.50	0.50

Figure 1 *Nozzle types Agrotop TDXL 80-015, TDXL 80-02 and TDXL-D 110-02 (left to right).*

2.1 Liquid distribution measurements

In accordance with the Measurement Protocol, the evenness of the liquid distribution below a sprayer boom was tested on a patternator, for the combinations of pressure, height and nozzle distance as given in Table 1. From these distributions, the coefficient of variation (CV) was determined on a basis of 0.10 m gutter widths. According the Measurement Protocol CV should be less than 10%.

At a nozzle spacing of 0.25 m, 10 nozzles could be placed above the patternator. At a nozzle spacing of 0.50 m, there was room for 5 nozzles. The patternator had gutters 0.025 m wide. Combining the liquid flow through 4 of these gutters, the coefficient of variation (CV) based on 0.10 m gutter width could be determined. The CV was computed over a width of 1.00 m at the centre of the patternator. Only combinations that would yield a CV lower than 10% were further investigated in spray drift simulations.

2.2 Drop size measurements

The flow rates of 10 nozzles of each type were measured. The 3 nozzles with flow rate closest to the median flow rate were selected for the drop size measurements. These 3 nozzles were used in measuring the drop size distributions using the PDPA equipment (Phase-Doppler Particle Analyzer; TSI). These drop size measurements were carried out in 3 repetitions. This gave 9 measurements per nozzle-pressure combination. This has to be done only for the combinations where on a spray patternator the coefficient of variation (CV) of the liquid distribution is less than 10%. The measurement chamber was climatized to 20^{o}C and a relative humidity of 70%. The spray liquid was tap water with a temperature of 20^{o}C. The details of the PDPA measurements are described in Annex 1.

Additionally, average droplet velocities were measured at the central axis of the spray cone, as a function of droplet size and distance below the nozzle outlet. From these velocities the entrained air flows were determine, which are required input for the IDEFICS spray drift simulations.

Finally, the Fine/Medium threshold nozzle for downward spray applications (Lurmark 31-03-F110 at 3 bar liquid pressure) of the British Crop Protection Council class classification (BCPC, Southcombe et al., 1997) was measured the same way. This reference nozzle is referred to as BCPC-F/M. The drop size distribution of the reference nozzle was measured on the same days on which the nozzle type to be examined were measured.

2.3 Spray drift computations

The results of the measurements of droplet size distribution and droplet velocities were used as input in the drift model IDEFICS (version 1.02; August 2022). According to the Measurement Protocol, for classification as drift-reducing nozzles the spray drift simulations a nozzle height of 0.50 m above the crop is required. This also includes nozzle types with top angles of 80-90 degree which are intended for use with a lowered sprayer boom (nozzle height 0.30m above the crop) and with a nozzle distance of 0.25 m. However, spray drift simulations for such low-boom conditions were carried out as well.

Furthermore, the following settings were applicable:
- location of the last nozzle 0.50 m inside the crop edge *;
- crop height of 0.50 m;
- forward speed of the sprayer 1.67 m/s (= 6.0 km/h);
- sprayer travelling parallel to the crop edge;
- wind direction perpendicular to the (downwind) crop edge;
- wind speed 3 m/s (at 2 m height);
- relative humidity 60%;
- air temperature 15^{o}C;
- neutral atmospheric stability (no thermal effects).

* This is based on a situation with a potato crop where the last ridge is located at 0.75 m from the ditch inlet; at a nozzle spacing of 0.50 m, the outer nozzle is at 0.125 m downwind from the centre of the last ridge; typically, the crop canopy extends up to the inlet. In the calculations with IDEFICS, to correct for a sloping crop canopy edge, the distance from the last nozzle to the crop edge was rounded to 0.50 m (see Figure 2).

Full-field simulations were performed in fivefold, with 30,000 droplets per nozzle, for 14 nozzles distributed over a spray treated width of 50 m. Interpolation and extrapolation for non-simulated nozzles allowed simulation of a full-field spray application.

The results of the model calculations gave deposition values of spray drift on consecutive ground strips with width 0.25 m, starting from the crop edge. These results were processed to average depositions on the evaluation strip 2.125-3.125 m from the last nozzle. This is the location of the water surface of the standardized ditch in the situation with a potato crop (Huijsmans et al., 1997; Figure 2).

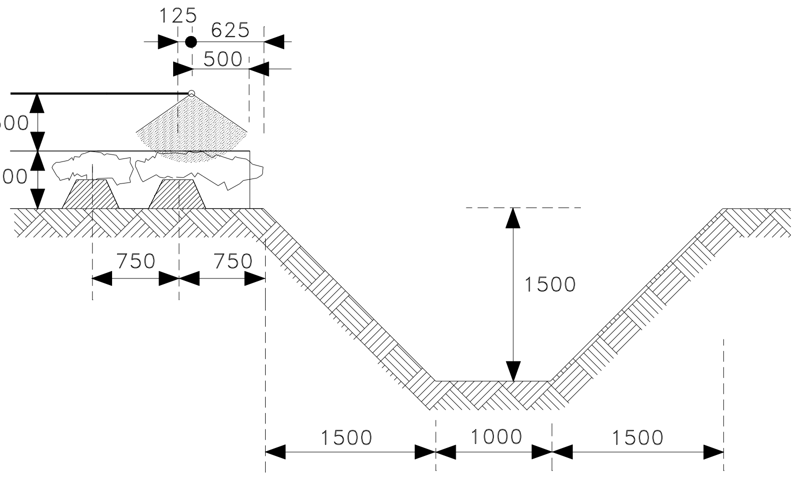

Figure 2 *Overview of the field situation for model calculations for a potato crop (dimensions in mm). In model calculations with lowered sprayer boom, nozzle heights of 300 mm were applied.*

2.4 Classification into drift reduction classes

Drift reduction was calculated by comparing the spray drift deposits for the full-field spray application with the nozzles to be tested and the deposits for the reference spray application using BCPC-F/M nozzles. Drift reduction classes with at least 50%, 75%, 90% and 95% drift reduction are distinguished.

Some statistical dispersion can be expected in various steps of the evaluation process: i.e. in the determination of the average droplet size spectra (which affects the calculated spray drift) and in the results of the spray drift simulations. The repeated measurements of droplet size distributions as well as the repeated spray drift simulations greatly reduce these uncertainties. It turns out that the uncertainty in the calculated drift values is about 1%. It can be deduced that at 75% drift reduction the uncertainty is about 0.4%, at 90% about 0.2% and at 95% about 0.1%. The current classification of nozzle-pressure combinations into drift reduction classes does not take this into account. Analogous to the classifications in Germany (Ganzelmeier and Rautmann, 2000) and England (Gilbert, 2000) and the assessment of results of field tests (ISO-22369, 2006; MinI&M, 2017), the absolute values 50, 75, 90 and 95% have been used to define the limits of the reduction classes.

3 Measurements

3.1 Liquid flow rate

The flow rate of ten nozzles of each nozzle type was measured at a liquid pressure of 3 bar. Three nozzles with flow rates closest to the median flow rate were indicated, in accordance with the Measurement Protocol. Table 2 shows the results. In the current study only one of these three nozzles was selected for measuring the drop size distribution.

Table 2 *Measured flow rates of 10 new nozzles and selection of 3 closest to the median flow rate; for the Agrotop TDXL nozzles at 3 bar liquid pressure.*

Nozzle type	**Nozzle number and flow rate [ml/min]**										**Median**	**Selected nozzles**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**[ml/min]**	
TDXL 80-015	617.5	607.5	607.5	612.5	615.0	620.0	607.5	607.5	610.0	620.0	611.3	2 4 9
TDXL 80-02	822.5	820.0	822.5	827.5	827.5	830.0	817.5	825.0	827.5	817.5	823.8	1 3 8
TDXL-D 110-02	820.0	825.0	817.5	820.0	825.0	822.5	822.5	822.5	817.5	825.0	822.5	6 7 8

3.2 Spray liquid distribution on a patternator

The liquid distribution for sprayer booms supplied with the nozzle types to be tested was measured on a spray patternator. The three nozzle types were tested at the specified liquid pressure, as shown in Table 3. The 80-degree nozzle types were tested at nozzle distance of 0.25 m and nozzle height of 0.30 m above the patternator, according to the Measurement Protocol for lowered-boom applications. The last nozzle type was tested for a standard application at nozzle distance of 0.50 m and nozzle height of 0.50 m. In all cases the coefficient of variation (CV) was below 10%.

Table 3 *Coefficient of variation (CV) of spray distribution on a patternator for the nozzle types Agrotop TDXL 80-015, TDXL 80-02 and TDXL-D 110-02, at the liquid pressure, nozzle distance and nozzle height as indicated.*

Nozzle type	**Pressure [bar]**	**Nozzle height [m]**	**Nozzle distance [m]**	**CV [%]**
TDXL 80-015	2	0.30	0.25	7.5
TDXL 80-02	3	0.30	0.25	6.1
TDXL-D 110-02	3	0.50	0.50	4.7

3.3 Drop size distribution

Drop size distributions were measured using a Phase Doppler Particle Analyzer (PDPA) as described in Annex 1. Table 4 shows the results of the drop size measurements with the PDPA system. Three nozzles of each Agrotop nozzle type were measured three times, the results represent the average of 9 measurements. The results of the reference nozzle is an averages of 6 measurements, which represent an average over the two days at which the different Agrotop nozzles were measured. The top angle of the flat fan spray cone is required for the spray drift simulations in the IDEFICS model and is added to the Table. The last column gives the average number of drops obtained in a single measurement. An overview of results for all drop sizing measurements is given in Annex 2.

Table 4 *Characteristic quantities of the measured drop size distributions, average droplet velocity and number of drops in each measurement. The reference nozzle BCPC-F/M is included. Measured using PDPA.*

Nozzle type	Pressure [bar]	D_{v10} [µm]	D_{v50} [µm]	D_{v90} [µm]	V_{100} [%]	v_{avg} [m/s]	Top angle [°]	Number of drops
BCPC-F/M ref	3	115.7	218.7	361.8	6.10	3.91	110	34700
TDXL 80-015	2	304.9	589.4	901.8	0.33	3.23	53	11700
TDXL 80-02	3	258.0	495.7	795.6	0.53	4.20	63	11400
TDXL-D 110-02	3	266.1	531.0	852.1	0.46	2.81	93	12500

3.4 Spray drift deposition and nozzle classification

The IDEFICS spray drift model was used to compute downwind spray drift deposits for a full-field treatment using a sprayer boom equipped with each of the Agrotop nozzle types in this study, at the requested liquid pressure. These spray drift deposits were compared to the deposits for a reference treatment using BCPC-F/M nozzles. The field layout was standardized: crop height 0.50 m, sprayer boom 0.50 m above the crop, first (outer) nozzle positioned at 0.50 m inside the crop edge. Each simulation was carried out 5 times, to improve accuracy and allow estimation of this accuracy. For the 80-degree nozzles, drift simulations at a lower nozzle height (0.30 m) were done as well (shown in italics), although this is not required for classification according to the Measurement Protocol.

The results are shown in Table 5. They indicate that at a liquid pressure of 3 bar all three nozzle types are within the class of 75% drift reducing nozzles (DRD75), for a nozzle height of 0.50 m. At lowered boom height (0.30 m) the spray drift reduction appears just to reach 95%.

Table 5 *Computed drift deposits and drift reductions at the location of the standardized ditch (1.625 – 2.625 m from the crop edge[1]), for the Agrotop nozzle types at the given liquid pressures. For crop height of 0.50 m and an outer nozzle position 0.50 m inside the crop edge. Drift reductions are computed with respect to the drift deposits of a reference treatment with BCPC-F/M nozzles. The corresponding classification is added as well.*

Nozzle type	Pressure [bar]	Nozzle distance [m]	Nozzle height [m]	Drift deposits [% dose]	SEM [2] [% dose]	Reduc [3] [%]	Potential reduction class			
							50%	75%	90%	95%
BCPC F/M ref	3	0.50	0.50	2.191	0.008	0	-			
TDXL 80-015	2	0.25	0.50	0.232	0.001	89		x		
			0.30	*0.088*	*0.001*	*96*				*x*
TDXL 80-02	3	0.25	0.50	0.269	0.002	88		x		
			0.30	*0.111*	*0.001*	*95*				*x*
TDXL-D 110-02	3	0.50	0.50	0.381	0.003	83		x		

1 This corresponds to a distance of 2.125-3.125 m from the outer nozzle.

2 SEM = standard error of mean, based on 5 independent drift simulations for each case.

3 Reduction is computed against the average drift deposits for a treatment using BCPC-F/M nozzles.

4 Conclusion

In this study the drift reducing capabilities of the nozzle types Agrotop TDXL 80-015 at a liquid pressure of 2 bar, and TDXL 80-02 and TDXL-D 110-02 both at 3 bar were examined. The first two nozzle types (in the group of nozzles with 80-90 degree top angles) are intended for use at a lowered sprayer boom. Evenness of the spray liquid distribution below a sprayer boom was tested on a patternator. The three examined nozzle-pressure combinations passed this test, yielding a coefficient of variation of less than 10%. From the results of spray drift simulations the drift reductions could be determined with respect to a reference spray application using BCPC-F/M nozzles. The examined nozzle-pressure combinations could be classified as 75% drift-reducing nozzle types (DRD75). Together with a lowered sprayer boom the 80-degree nozzles reached a drift reduction of 95%.

Classification for downward application
For the classification based on the current DRD measurement protocol, only the situations with nozzle height 0.50 m and outer nozzle at position 0.50 m from the crop edge are relevant, also for nozzle types to be used with a lowered sprayer boom. The following nozzle-pressure combinations in this study appear to qualify for classification as DRD75:
- TDXL 80-015 at 2 bar (at nozzle spacing of 0.25 m)
- TDXL 80-02 at 3 bar (at nozzle spacing of 0.25 m)
- TDXL-D 110-02 at 3 bar

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Annex 1 PDPA drop size measurements

The droplet size spectrum of spray nozzles was determined with a Phase Doppler Particle Analyzer (PDPA, TSI). The spray liquid was tap water with a temperature of 20°C. The climate chamber was set to a temperature of 20°C and a relative humidity of 70%. During the measurement, the nozzle position described a trajectory of 11 parallel paths (Figure A.1). The length of the paths and the distance between paths were set in such a way that the paths covered the total spray pattern well. The moving speed of the nozzle along the paths was adjusted in such a way that at least 10,000 drops were measured per measurement. The nozzle height was 0.30 m above the measuring plane. The measurement height above the floor was 0.70 m.

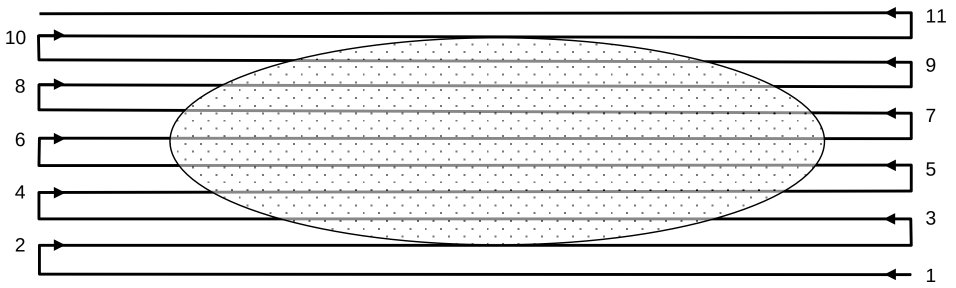

Figure A.1 *Pattern of paths along which the tested nozzle was moved to obtain the drop size distribution averaged over the cross-sectional area of the spray cone in a horizontal plane 0.30 m below the nozzle. Length of the paths and distance between parallel paths were adjusted to fit the cross-section of the spray. Path no. 6 crosses the centre of the spray.*

The PDPA settings were:

• Laser power at measuring point	25 mW
• Focus front lens of transmitter	1000 mm
• Focus front lens of detector	1000 mm
• Expander/contractor	contractor
• Detection angle	40°
• Detector voltage	540 V
• Signal threshold	50 mV
• Measuring range	5 - 1250 µm
• Diameter resolution	2,4 µm
• Probe Volume Correction	yes

The laser power was checked at the start of each measurement and adjusted if necessary. The proper coupling of the laser beams into the glass fibers of the so-called 'fiber drive' was also checked before each measurement, since this fiber connection is sensitive to temperature changes and vibrations. In all cases the laser power in the measurement point was the major quantity to keep constant: this power was kept constant at the stated value of 25 mW.

The results of the drop sizing measurements are presented as D_{V10}, D_{V50}, D_{V90} and V_{100}. These quantities are defined as follows:

- D_{V10} [µm]: 10% of the spray volume consists of droplets with a diameter less than D_{V10};
- D_{V50} [µm] = VMD [µm] (Volume Median Diameter): 50% of the spray volume consists of droplets with a diameter less than D_{V50};
- D_{V90} [µm]: 90% of the spray volume consists of droplets with a diameter less than D_{V10};D_{V90};
- V_{100} [%]: volume fraction of the spray consisting of droplets with diameter less than 100 µm.

Annex 2 Measurements of droplet sizes

In Table A.1 an overview is given of drop size measurements for the reference nozzle type BCPC-F/M, on the same dates on which the Agrotop nozzles were measured. These reference measurements were combined to the drop size spectrum of the BCPC-F/M to be used in the IDEFICS spray drift simulations.

In Table A.2 an overview is given of drop size measurements for nozzle type Agrotop TDXL 80-015 at 2 bar liquid pressure. Similarly, Table A.3 shows the drop size measurement for TDXL 80-02 at 3 bar liquid pressure and Table A.4 those for TDXL-D 110-02 at 3 bar liquid pressure. The averaged drop size spectra were used in the IDEFICS spray drift simulations.

Table A.1 *Overview of the drop size characteristics for the BCPC-F/M threshold nozzle at 3 bar liquid pressure; measured using PDPA at the same dates on which the Agrotop nozzles were tested.*

Run	Date	D_{V10} [µm]	D_{V50} [µm]	D_{V90} [µm]	V_{100} [%]	v_{avg} [m/s]	Droplet count
1	12-1-2023	114.2	215.9	355.1	6.39	4.00	35800
2		115.9	220.2	373.7	6.13	3.91	34500
3		115.1	216.2	354.3	6.29	3.81	34800
4	20-1-2023	114.7	217.3	352.6	6.21	3.93	34600
5		118.4	221.9	372.9	5.50	3.88	33500
6		115.7	220.8	362.2	6.07	3.90	34900
	average	**115.7**	**218.7**	**361.8**	**6.10**	**3.91**	**34700**

Table A.2 *Overview of the drop size characteristics for nozzle type Agrotop TDXL 80-015 at 2 bar liquid pressure; measured using PDPA.*

Run	Nozzle index	Date	D_{V10} [µm]	D_{V50} [µm]	D_{V90} [µm]	V_{100} [%]	v_{avg} [m/s]	Droplet count
1	2	12-1-2023	299.0	581.8	898.6	0.36	3.29	13200
2	4		302.4	586.9	878.4	0.31	3.28	11300
3	9		305.2	589.9	879.6	0.33	3.16	11500
4	9	20-1-2023	318.5	614.3	942.3	0.29	3.19	11000
5	4		318.1	606.6	940.4	0.30	3.16	11000
6	2		294.8	568.3	894.6	0.35	3.28	12300
7	2		289.5	557.4	835.4	0.38	3.29	12600
8	4		307.9	603.3	888.8	0.31	3.19	11200
9	9		308.4	596.0	957.8	0.31	3.20	11000
		average	**304.9**	**589.4**	**901.8**	**0.33**	**3.23**	**11700**

Table A.3 *Overview of the drop size characteristics for nozzle type Agrotop TDXL 80-02 at 3 bar liquid pressure; measured using PDPA.*

Run	Nozzle index	Date	D_{V10} [µm]	D_{V50} [µm]	D_{V90} [µm]	V_{100} [%]	v_{avg} [m/s]	Droplet count
1	1	20-1-2023	251.8	484.1	734.1	0.57	4.14	11000
2	3		255.2	491.9	762.2	0.55	4.18	11800
3	8		259.8	498.7	798.3	0.52	4.26	11300
4	8		259.6	507.2	812.5	0.52	4.18	11500
5	3		259.4	496.6	829.3	0.56	4.11	12000
6	1		255.9	489.7	798.9	0.54	4.21	11000
7	1		259.8	505.5	858.1	0.53	4.14	11300
8	3		259.9	496.5	783.4	0.49	4.24	11000
9	8		260.6	491.5	783.6	0.52	4.31	11400
		average	**258.0**	**495.7**	**795.6**	**0.53**	**4.20**	**11400**

Table A.4 *Overview of the drop size characteristics for nozzle type Agrotop TDXL-D 110-02 at 3 bar liquid pressure; measured using PDPA.*

Run	Nozzle index	Date	D_{V10} [µm]	D_{V50} [µm]	D_{V90} [µm]	V_{100} [%]	v_{avg} [m/s]	Droplet count
1	6	20-1-2023	263.4	533.9	875.8	0.50	2.77	13500
2	7		263.6	531.2	855.9	0.49	2.76	12600
3	8		265.2	531.4	821.6	0.45	2.85	12200
4	8		268.9	535.6	884.8	0.41	2.86	12000
5	7		269.4	532.0	874.4	0.47	2.80	12700
6	6		268.8	535.4	844.4	0.42	2.86	12200
7	6		264.1	524.1	827.6	0.48	2.83	12700
8	7		268.0	536.4	869.4	0.46	2.77	11900
9	8		263.5	519.2	814.8	0.49	2.78	12600
		average	**266.1**	**531.0**	**852.1**	**0.46**	**2.81**	**12500**

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