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EFFECT OF SPRAY APPLICATION PARAMETERS ON THE AIRBORNE DRIFT[1]

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ABSTRACT

The objective of the study was to determine the effect of the spray boom height and liquid pressure on airborne drift during spray application. A lift mounted sprayer with a 12 m spray boom and standard flat fan nozzles LU 120-03 (Lechler) was used in the field trials. The treatments were made for all combinations of the boom heights 0.35, 0.5 and 0.75 m, and liquid pressures 0.15, 0.3 and 0.5 MPa. For each treatment the sprayer was driven at the velocity of 6.0 $km\cdot h^{-1}$, five times over the distance 60 m. The fluorescent dye BSF was sprayed and collected on the samples attached on 4 m masts. The analysis of BSF deposition on the samplers proved the significant effect of both the boom height and the liquid pressure on the airborne drift. The lowest drift was observed for the pressure of 0.15 MPa regardless the boom height. For these parameters the drift was reduced by 50% compared to the standard situation with the boom height of 0.5 m and the pressure of 0.3 MPa. Raising the boom up to 0.75 m and the pressure to 0.5 MPa resulted in 270% increase of the drift.

Introduction

The quality of the crop protection treatment, namely the uniform distribution of the crop protection products applied on the pests or pathogens infected vegetative organs of plants, which ensured high biological effectiveness, has been the basic objective of the protection technique until recently. However, numerous cases of environmental pollution by crop protection products in regions, where intensive plant production was carried out forced out care for natural environment. Also in Poland for the last dozen or so years, provisions concerning the use of crop protection chemicals, which impose on the operator of sprayers the obligation to obey numerous limitations e.g. the use of buffer zones, have changed. Also,

1 The research was carried out within measure no. 1.20 "Development of crop protection chemicals precise application method in order to limit pollution of water, soil and other elements of environment" of the Multiannual Programme *"Development of sustainable methods of horticultural production in order to ensure high biological and nutritive quality of horticultural products and to maintain biodiversity and protection of their resource" financed by the Ministry of Agriculture and Rural Development.*

the EU directive on sustainable use of pesticides obliges the Member States to limit threats related to their use with regard to people and natural environment (Directive of the European Parliament and the Council 2009/128/EC of 21st October 2009). One of the biggest threats for water and aquatic organisms is an unavoidable side phenomenon of the spraying process, which is spray drift (Doruchowski and Hołownicki, 2003).

The quality of the treatment and spray drift are two important issues of the crop protection technique. The quality of the treatment is significant in the aspect of spray coverage which to a great extent depends on the type of nozzles, their dimensions and working pressure, and hence droplet size. On the other hand the size of droplets as well as speed and direction of the spray jet affect sedimentation and airborne drift (Van de Zande et al., 2008; Zhu et al., 1994; Knewitz et al., 2002; Castell, 1993; Ganzelmeier, 2000). Measurement of sedimentation drift distribution is significant for assessment of the risk of surface water contamination, while measurements of the airborne drift profile are used to assess the risk with reference to inhalation effects and contamination of plants with an extended spatial form within the field borders (Miller et al., 1989; Taylor and Anderson, 1991). Atmospheric conditions i.e. wind velocity, air temperature and humidity are significant factors which influence both sedimentation and airborne drift (Nuyttens et al., 2006). According to literature the airborne drift decreases along with the increase of the height on which samples are placed, whereas it increases along with the increase of the wind velocity (Guler et al., 2007). While the sedimentation drift was the object of numerous works, few results of research concerning airborne drift are available. Thus, in the Agro-Engineering Dept of the Research Institute of Horticulture in Skierniewice such investigations for various spraying techniques were undertaken.

The objective of the research

The objective of the research was to determine the impact of spray boom operation height and spray pressure on airborne drift.

Methodology of research

Measurements of airborne drift were carried out with the lift-mounted sprayer, equipped with a 12 m spray boom and a 400 l tank. Lechler LU 120-03 nozzles were mounted on the spray boom. The sprayer was driven at travel velocity 6.0 $km \cdot h^{-1}$ on 60 m long test plot. For each combination of the spray boom height (0.35; 0.5; 0.75 m) and working pressure (0.15; 0.3; 0.5 MPa) the sprayer was passing five times over the plot while spraying a water soluble fluorescent dye (BSF) at the concentration 0.3%, according to methods used in drift tests (Bode et al., 1976; Van De Zande et al., 2000; Heijne et al., 2002). Sensitive fluorometric techniques ensure detecting vary small amounts of BSF collected on samplers in form of droplets smaller than 100 μm, or dry particles remaining after evaporation of water from the droplets (Arvidsson et al., 2011). During the field trials, wind velocity with a perpendicular direction to the sprayer driving direction, temperature and air humidity were recorded. Airborne drift was collected on four samplers in form of porous balls (plastic dish washers, 70 mm in diameter) attached on the masts located 5 m from the border of the treated plot, i.e. from the last nozzle on the spray boom. The lowest sampler was 1 m above the ground and the top one at 4 m height (Fig. 1). Two masts with two vertical lines of samplers (Fig. 2) were used to make for four replications of spray collectors at each height.

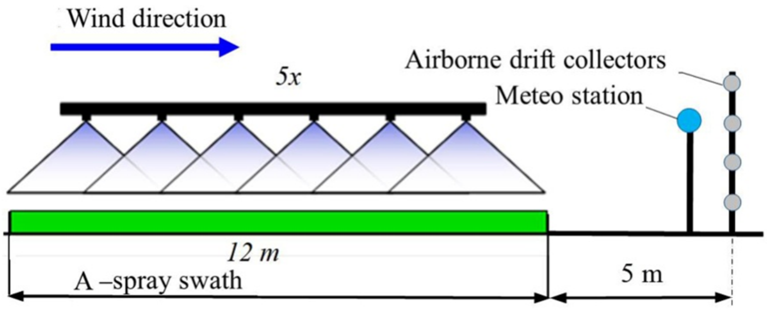

Figure 1. Layout of experiment

Fluoroscent dye was extracted from each sampler separately in tight plastic couvettes in the volume of 400 ml of deionaised water. After the 15 minute shaking a uniform solution of a fluorescent dye was subjected to the measurement of BSF concentration with the use of spectrofluorometer PerkinElmer LS 55. The obtained results were expressed in percentage of the applied dose of a fluoroscent dye. A two-factor analysis of variance and Duncan's range test at the level of significance of P = 0.05 was carried out on data transformed according to Box-Cox with parameter λ = - 0.211098:

$$X'_{\lambda} = (x^{\lambda} - 1) \cdot \lambda^{-1}$$

Figure 2. Airborne drift collectors on mast

Table 1
The wind velocity, relative humidity and temperature during the field tests

Parameters	Spray boom height (m)								
	0.35			0.5			0.75		
Liquid pressure (MPa)	0.15	0.3	0.5	0.15	0.3	0.5	0.15	0.3	0.5
Wind speed ($m \cdot s^{-1}$)	2.6	3.0	3.0	1.2	2.1	2.7	1.0	2.4	2.3
Relative humidity (%)	50	49	44	54	40.5	42	57.8	39.5	38.4
Air temperature (ºC)	30	24.3	24.3	29.2	25.3	25.5	27.1	26	26.9

Research results

Table 1 presents data on meteorological conditions during the test treatments and figures 3, 4, 5 and 6 show the graphs of drift profiles representing the distribution of airborne drift. Regardless the height of spray boom, the lowest airborne drift was obtained for pressure of 0.15 MPa (Fig. 6).

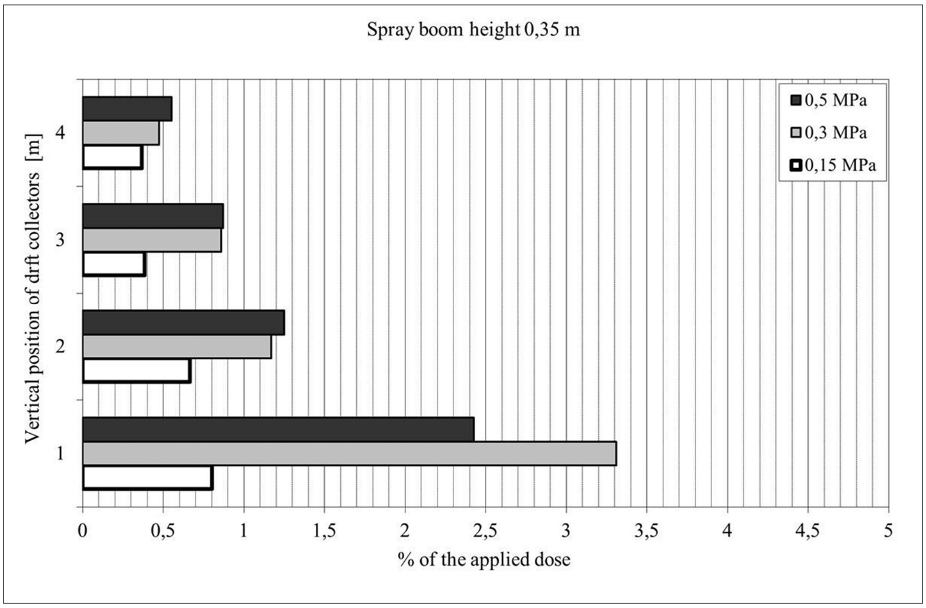

Figure 3. Airborne drift profile for spray boom height 0.35 m

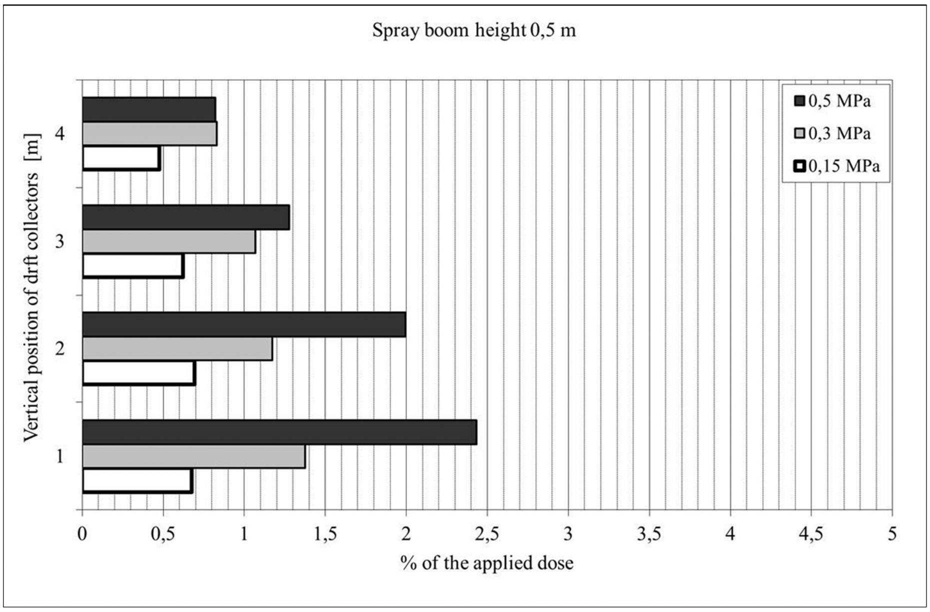

Figure 4. Airborne drift profile for spray boom height 0.5 m

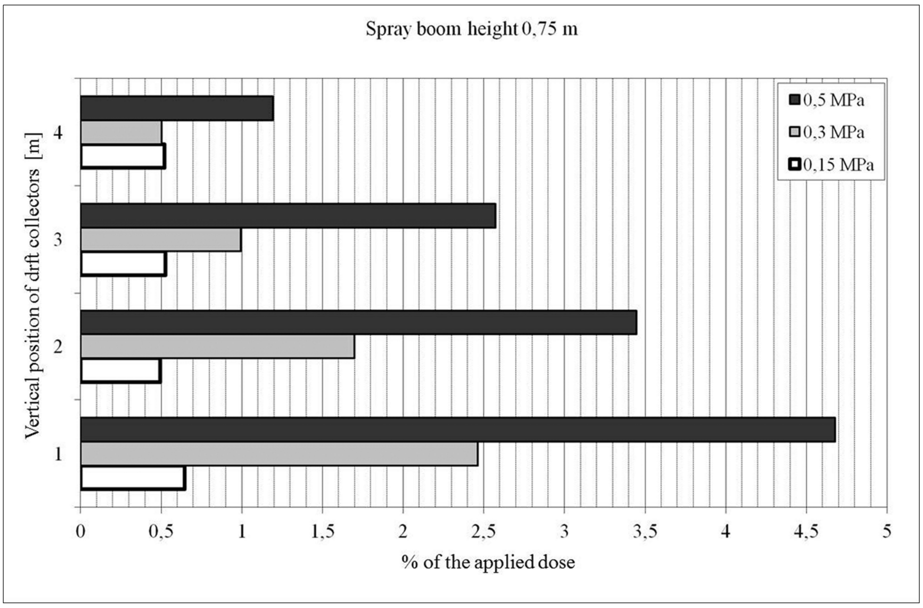

Figure 5. Airborne drift profile for spray boom height 0.75 m

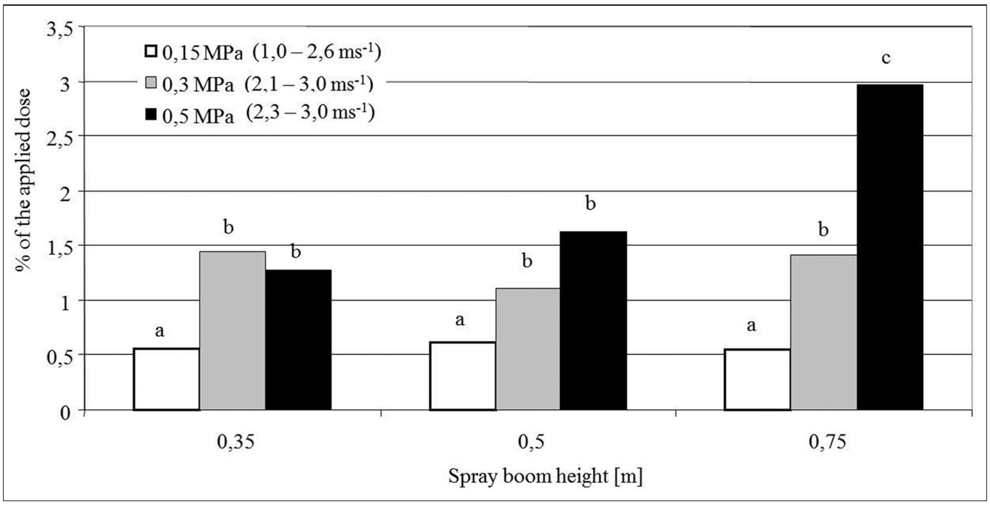

Figure 6. Total airborne drift (average values followed by the same letters do not differ significantly according to Duncan's Test, p=0.05)

Reduction of fraction of spray droplets smaller than 100 μm by decreasing of pressure in the sprayer liquid system to 0.15 MPa caused reduction of airborne drift almost by 50% in comparison to a standard spraying technique (height of a spray boom 0.5 m and pressure of 0.3 MPa). For this low pressure and all heights of the spray boom the drift measured on particular heights of samplers location was lower than that obtained at pressures of 0.3 and 0.5 MPa (Fig. 3, 4 and 5). Despite the expectations for the standard height (0.5 m) and the lowered height (0.35m) of a spray boom no significant differences of airborne drift were observed at pressures of 0.3 and 0.5 MPa. The spray boom raised to 0.75 m at the pressure of 0.3 MPa also had no significant effect on spray airborne drif. Only the increase of pressure to 0.5 MPa for the highest boom level caused a significant increase of airborne drift. In comparison to the standard spraying technique, airborne drift increased then by 270%. Regardless the height of samplers location, the increase of pressure to 0.5 MPa caused a considerable increase of drift in comparison to lower pressures. In case the samplers were placed at the height of 1 and 2 meters over the ground, airborne drift was almost two times higher for the pressure of 0.3 MPa and seven times higher for the pressure of 0.15 MPa (Fig. 5). For samplers location of 3 meters the drift was 2.5 times higher for pressure of 0.3 MPa and 5 times higher for pressure of 0.15 MPa, whereas for location of samplers at the height of 4 meters, 2.5 times higher than for two remaining pressures. Moreover, according to expectations, along with the increase of samplers' location, reduction of airborne drift for all combinations of the spray boom control and use of working pressures was reported.

Conclusions

1. Reduction of pressure in the liquid system of a sprayer to 0.15 MPa caused the spray airborne drift reduction by 50% in comparison to the standard technique (height of a spray boom 0.5 m and pressure of 0.3 MPa) regardless the height of spray boom.
2. Raising the height of spray boom up to 0.75 m and the liquid pressure to 0.5 MPa increased airborne drift by 270 % with reference to a standard spraying technique.
3. The high spray boom and high pressure resulted in a considerable increase of airborne drift on all measured heights.

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WPŁYW PARAMETRÓW ROBOCZYCH OPRYSKIWACZA POLOWEGO NA ZNOSZENIE POWIETRZNE

Streszczenie. Celem prezentowanych badań było określenie wpływu wysokości belki polowej i ciśnienia roboczego na znoszenie powietrzne cieczy użytkowej. W badaniach zastosowano opryskiwacz zawieszany, wyposażony w standardową belkę polową o szerokości roboczej 12 m i rozpylacze Lechler LU 120-03. Zabiegi opryskiwania prowadzono na odcinku testowym o długości 60 m i szerokości roboczej opryskiwacza ze stałą prędkością roboczą 6,0 km·h^{-1}. Dla każdej kombinacji wysokości ustawienia belki polowej (0,35; 0,5; 0,75 m) i ciśnienia roboczego (0,15; 0,3; 0,5 MPa) wykonano 5 przejazdów odcinka testowego nanosząc znacznik fluorescencyjny. Naniesienie znacznika oceniane było na próbnikach rozmieszczanych na masztach o wysokości 4 m. Wyniki badań potwierdzają istotny wpływ wysokości pracy belki i ciśnienia cieczy użytkowej na znoszenie powietrzne. Najmniejsze znoszenie powietrzne uzyskano dla ciśnienia 0,15 MPa i to niezależnie od wysokości ustawienia prowadzonej belki polowej. W porównaniu ze standardową techniką opryskiwania (wysokość belki 0,5 m ciśnienie 0,3 MPa) uzyskano redukcję znoszenia powietrznego o 50%. Nadmierna wysokość prowadzenia belki polowej 0,75 m i wysokie ciśnienie 0,5 MPa spowodowało wzrost znoszenia powietrznego o 270%.

Słowa kluczowe: znoszenie powietrzne, belka polowa, rozpylacze, ciśnienie cieczy