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SPRAY COVERAGE ON APPLE LEAVES OBTAINED BY DIFFERENT NOZZLES AND ADJUVANTS

Richard Holownicki, Greg Doruchowski, Waldemar Œwiechowski, Artur Godyñl
Research Institute of Pomology and Fliriculture, Skierniewice, Poland

Abstract: The tendencies of increasing the droplet size to reduce the spray drift and emission of pesticides to the environment and observed recreantly. It can be confirmed by the increased interest of fruit growers in use of air-inclusion nozzles producing very coarse droplets (VMD=400-600 μm). The influence of droplet size on biological efficiency of chemical protection was a subject of many earlier studies. Still there are doubts about recommending the use of coarse droplets for insecticide and acaricide applications. The poorer biological efficiency observed for air-inclusion than for the conventional nozzles can be explained by the lower spray coverage and spray density. In order to facilitate this recommendation the VarioWindSelect system of automatic adjustment of nozzles types according to the wind velocity was developed. The objective of the described experiment was to test this hypothesis and to compare the natural and artificial targets used for evaluation of spray coverage.

Key words: *orchards, pesticide, nozzles, spray coverage, VarioWIndSelect system.*

INTRODUCTION

The tendencies of increasing the droplet size to reduce the spray drift and emission of pesticides to the environment are observed recreantly. It can be confirmed by the increased interest of fruit growers in use of air-inclusion nozzles producing very coarse droplets (VMD=400÷600 μm). The influence of droplet size on biological efficacy of chemical protection was a subject of many earlier studies. A lower biological effect of herbicides applied with coarse droplets produced by air-inclusion nozzles was observed in field crops (Jensen, 2002; Wolf, 2000). Though, there were experiments showing that the coarse droplets gave a similar disease control in orchard as the fine ones, produced by the conventional hollow cone nozzles (Heinkel et al., 2000; Knewitz et al., 2002), there are still doubts about recommending the use of coarse droplets for insecticide and acaricide applications (Frießleben, 2003). The poorer biological efficacy observed for air-inclusion than for the conventional nozzles can be explained by the lower spray coverage and spray density. Therefore, to optimise spray application fine droplets should be used at a calm weather, and coarse ones at windy condition. In order to facilitate this recommendation the VarioWindSelect system of automatic adjustment of nozzle types according to the wind velocity was developed (Holownicki et al., 2004).

Though, the coarse droplets are less prone to drift, they have a higher tendency to rebound on the leaf surface and they give lower spray coverage than the fine ones and usually lower biological efficacy of the treatment. The adjuvants can reduce this disadvantageous effect. They have a very wide range of effects, such as surface wetting and droplet spreading, increasing rainfastness, changing the physical form of the deposits, increasing the biological activity and enhancing the penetration of active ingredient (Spanoghe et. al., 2002). The influence of spray liquid properties on droplet size and spray drift were also a subject of previous experiments. These result showed no consistent influence of spray characteristics on droplet size and spray drift. According to Butler Ellis & Tuck (2000) it is not possible to measure surfactant properties and predict the effect. It was found that all conventional adjuvants produce similar drift profiles at distances greater than 2 m from the nozzles and the formulation changes have no practical meaning (Butler Ellis & Bradley, 2002). The earlier experiments on the use of adjuvants were not sufficient to deduce on the influence of droplet size on spray coverage obtained by air inclusion nozzles assembled on the air-assisted orchard sprayers.

It has been assumed that the addition of adjuvants improve spray coverage obtained by coarse droplets from the air-inclusion nozzles compared to fine ones from conventional hollow cone nozzles. The objective of the described experiment was to test this hypothesis and to compare the natural and artificial targets used for evaluation of spray coverage.

MATERIALS AND METHODS

Three nozzle sizes (01, 02, 03) and two nozzle types were compared: conventional hollow cone TR80 (Lechler) and flat fan air-inclusion ID90 (Lechler). The water solution of fluorescent tracer (Tinopal) at the concentration 1.5% was sprayed out with cross-flow sprayer with tangential fan (Holder) at a travel speed 7.2 km/h (fig. 1). Spray coverage was evaluated on 10 apple leaves (cv. Jonagold) and 10 WSP (Water Sensitive Paper), attached to the vertical frame. The samples were sprayed with the water solution of the fluorescent dye alone and with addition of three commonly used adjuvants: Agral 90 (polyethoxylated nonylphenol surfactant), Silwet L-77 (polyethoxylated hepatamethyl trisiloxane) and Greemax (Alpha-butyl-omega-hydroxypoly block polymer).

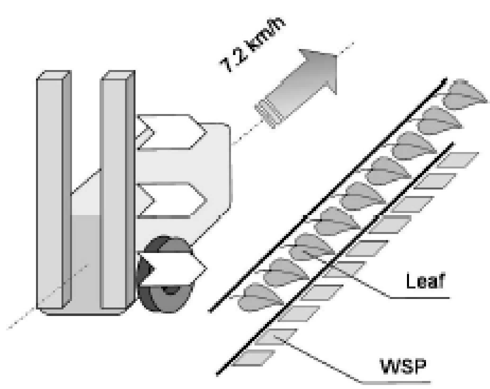

Figure 1. Layout of the outdoor tests

The first two were applied at the concentration 0.05; 0.1; 0.15% and the third one at 0.025; 0.05; 0.075%, according to recommendations. After the treatments the samples were digitally photographed in UV light.

The spray coverage on leaves (fig. 2) and WSP collectors, measured with image analysis system was presented as a percentage of target area covered by spray spots. The image analysis was also used to measure the droplet density expressed by the number of spots per unit area (n cm^{-2}).

Table 1. Spraying parameters

Nozzle type	Nozzle size	Pressure (bar)	Flow rate (l/min)	Size class* (BCPC)
Hollow cone TR80	01	0.68	0.54	Fine
	02	0.58	1.04	Fine
	03	0.55	1.54	Medium
Flat fan air-inclusion ID90	01	0.68	0.54	Very Coarse
	02	0.58	1.04	Very Coarse
	03	0.55	1.54	Very Coarse

(*) – for tap water according to Lechler GmbH

Table 2. Spray coverage (%) on apple leaves and water sensitive paper (WSP) for conventional hollow cone and flat fan air-inclusion nozzles at different adjuvants concentrations (2005)

Target		Leaves				WSP			
Concentration (%)		0	0.05	0.10	0.15	0	0.05	0.10	0.15
Silwet L-77	TR 80-01	6.5 a	9.8 bc	10.5 bc	11.0 c	10.0 c	11.0 c	9.5 c	6.1 ab
	ID 90-01	6.7 a	11.5 c	5.5 ab	12.0 c	2.6 a	5.2 ab	5.8 bc	9.8 c
	TR 80-02	9.2 ab	14.2 cd	15.1 cd	14.6 cd	7.7 a	18.3 bd	10.8 ab	10.1 ab
	ID 90-02	6.0 a	11.7 bc	16.5 d	17.6 d	13.0 ac	20.0 cd	22.2 d	12.9 ad
	TR 80-03	12.5 b	13.5 bc	13.5 bc	16.9 c	15.5 a	15.6 a	18.7 a	12.9 a
	ID 90-03	7.3 a	14.6 bc	16.4 bc	14.9 bc	14.4 a	10.0 a	10.4 a	10.2 a
Agral 90	TR 80-01	8.5 a	19.9 c	14.2 b	21.4 c	10.0 c	7.9 ac	2.9 ab	7.2 ac
	ID 90-01	8.7 a	10.5 b	14.0 b	14.6 b	2.6 a	3.7 ab	6.9 ac	5.2 bc
	TR 80-02	9.2 a	17.2 b	16.8 b	16.2 b	7.7 ab	12.1 ab	9.9 ab	6.6 ab
	ID 90-02	8.0 a	16.5 b	15.2 b	16.0 b	13.0 b	9.7 ab	6.4 a	8.2 ab
	TR 80-03	12.5 b	21.2 ce	20.7 cc	22.6 dc	15.5 bc	16.2 bc	14.8 bc	9.3 ac
	ID 90-03	7.3 a	17.6 cd	16.9 bc	24.7 c	14.4 bc	5.8 a	7.8 ab	16.8 c
Concentration (%)		0	0.025	0.05	0.075	0	0.025	0.05	0.075
Gromax	TR 80-01	6.5 a	17.5 d	16.6 cd	16.7 d	10.0 b	6.2 ab	8.8 ab	7.5 ab
	ID 90-01	6.7 a	9.6 ab	11.9 bc	14.5 cd	2.6 a	6.8 ab	8.1 ab	2.6 a
	TR 80-02	9.2 a	19.9 bc	16.2 b	23.9 c	7.7 a	10.7 a	8.8 a	12.5 a
	ID 90-02	6.0 a	16.7 b	16.9 b	17.6 b	13.0 a	14.3 a	16.2 a	9.7 a
	TR 80-03	12.5 b	17.9 cd	17.6 cd	27.7 c	15.5 a	13.1 a	19.8 a	10.3 a
	TR 80-03	7.3 a	19.5 cd	16.2 bc	21.4 d	14.4 a	18.1 a	12.4 a	12.1 a

Values in columns for the same adjuvant and nozzle size followed by the same letter do not differ significantly (Duncan's Multiple Range Test, P<0.05)

RESULTS AND DISCUSSION

In general there were no significant influence of nozzle type on spray coverage on apple leaves. Only for the treatments without addition of adjuvants a higher spray coverage was observed for the biggest conventional hollow cone nozzles (03) than for air-inclusion ones.

The adjuvants even at the lowest concentration considerably increased the coverage on leaves. The higher adjuvant concentrations brought only the slight increase of leaf coverage by spray liquid. By the increased spreading of spray droplets on the target the adjuvants almost doubled the spray coverage obtained by the air-inclusion nozzles. Much smaller increase of coverage was observed for conventional hollow cone nozzles. No influence of adjuvants on spray coverage on WSP was observed due to the properties of the target surface. Therefore artificial targets are less suitable for spray coverage measurements.

Table 3. Droplets density (n/cm^2) on apple leaves and water sensitive paper (WSP) for conventional hollow cone and flat fan air-inclusion nozzles at different adjuvants concentrations

Target		Leaves				WSP			
Concentration (%)		0	0.05	0.10	0.15	0	0.05	0.10	0.15
Silwet L-77	TR 80-01	122 d	116 cd	110 cd	104 c	84 b	127 c	176 d	95 b
	ID 90-01	35 a	47 a	70 b	38 a	32 a	32 a	21 a	43 a
	TR 80-02	100 c	113 d	94 c	104 cd	82 b	129 c	108 b	147 c
	ID 90-02	44 a	69 b	40 a	36 a	23 a	19 a	29 a	40 a
	TR 80-03	101 d	114 d	105 d	103 d	128 c	80 b	136 c	132 c
	ID 90-03	36 a	69 bc	61 b	70 bc	41 a	26 a	29 a	36 a
Agral 90	TR 80-01	122 d	106 d	84 c	114 d	84 bd	58 cd	66 ac	122 d
	ID 90-01	35 a	47 a	75 bc	63 b	32 ab	14 a	45 ac	20 a
	TR 80-02	100 cd	90 c	112 d	101 cd	82 b	88 b	88 b	84 b
	ID 90-02	44 a	65 b	44 a	57 ab	23 a	30 a	20 a	32 a
	TR 80-03	101 d	95 c	105 d	88 c	128 c	112 c	121 c	80 b
	ID 90-03	36 a	60 b	57 b	60 b	41 ab	25 a	28 ab	67 b
Concentration (%)		0	0.025	0.05	0.075	0	0.025	0.05	0.075
Greemax	TR 80-01	122 d	133 d	155 e	92 c	84 bc	58 cd	129 dc	146 c
	ID 90-01	35 a	73 b	67 b	39 a	32 a	27 a	44 ab	21 a
	TR 80-02	100 d	140 e	130 e	90 cd	82 b	89 b	136 c	117 bc
	ID 90-02	44 a	72 bc	79 bc	67 b	23 a	28 a	23 a	31 a
	TR 80-03	101 dc	117 ef	131 f	97 d	128 c	92 b	170 c	147 c
	ID 90-03	36 a	95 cd	76 c	55 b	41 a	29 a	19 a	47 a

The droplet density (Table 3), expressed by the number of spots per unit area, can be a complementary measure of spray treatment quality. The two or three fold higher spray densities were observed for tap water and conventional hollow cone nozzles than for air inclusion ones. The addition of adjuvant at the lowest concentration noticeably increased the spot density for air-inclusion nozzles, except Silwet nad Agral application with 01 nozzles.

The reduction of spot densities were observed for some treatments at maximum concentration in comparison to the lower ones due to spot overlap caused by increased spreading of spray drops. Increased spot density for the air-inclusion nozzles at the same flow rate can be explained by the reducing of droplet size. Though, the droplets size and spray drift were not measured in the presented experiments, the previous studies showed, that Agral (0.1%) decreased VMD of droplets produced by 02 Injet nozzles by more than 10% (Powell et al., 2002) and the formulation changes for air-inclusion nozzles were of no practical significance on spray drift (Butler Ellis & Bradley,2002). It means that the enhancement of spray coverage were mainly due to the altered properties of spray liquid and the addition of adjuvants can be a way to improve spray coverage without increasing spray drift.

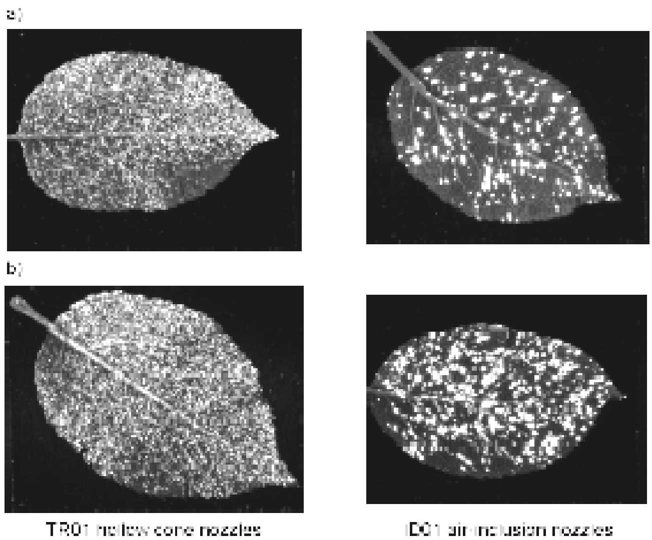

Figure 2. Spray coverage on apple leaves (examples):
a) without adjuvant, b) with adjuvant

Significantly higher spot densities on WSP were observed for conventional hollow cone nozzles. However, the addition of adjuvants did not bring any noticeable effect on droplet density. The measurements made on leaves were more reliable than those on WSP and showed sharper differences in spray coverage between conventional hollow cone and flat fan air-inclusion nozzles.

CONCLUSION

The presented study showed that the adjuvants applied with air-inclusion nozzles improve the spray coverage on apple leaves. It may have both biological and ecological impact. Measurement of spray coverage on leaves gave more contrasting results. Analysis of digital image of fluorescent tracer coverage on leaves can be used as a method to study the influence of adjuvants on spray treatment quality.

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UTICAJ TIPOVA RASPRŠIVAČA I ADITIVA NA EFIKASNOST PRIMENE PESTICIDA U ZASADIMA JABUKE

Richard Holownicki, Greg Doruchowski,
Waldemar Œwiechowski, Artur Godyñl

Research Institute of Pomology and Fliriculture, Skierniewice, Poland

Sadržaj: U skorije vreme se primećuje tendencija povećanja veličine kapi radi smanjenja drifta i smanjenja emisije pesticida u životnu sredinu. Ovo se može potkrepiti činjenicom da se sve veći broj proizvođača voća interesuje za raspršivače lepezastog mlaza koji proizvode grubi sprej (VMD=400- 600 μm). Veliki broj autora se bavio proučavanjem uticaja veličine kapi na biološku efikasnost hemijskih sredstava za zaštitu bilja. Ipak, još uvek postoje sumnje kada se radi o preporučivanju grubih sprejeva u aplikaciji insekticida i akaricida. Slabiji biološki efekat raspršivača sa lepezastim mlazom u odnosu na konvencionalne raspršivače se može objasniti slabijim prekrićem i gustinom spreja. Kako bi se olakšala ovakva preporuka, razvijen je VarioWindSelect sistem za automatsko podešavanje tipa raspršivača u zavisnosti od jačine vetra.

Cilj opisanog eksperimenta je da se ispita ova hipoteza i da se uporede prirodne i veštačke mete koje su korišćene za ocenu prekrića. Ispitivanje je obuhvatilo tri veličine raspršivača (01, 02, 03) i dva različita tipa raspršivača - konvencionalni sa šupljim konusom TR80 (Lechler) i raspršivač sa ravnim lepezasti mlazom ID90 (Lechler). U vodeni rastvor je stavljen fluorescentni trejser (Tinopal) u koncentraciji 1.5%. Tokom ispitivanja je korišćen orošivač sa tangencijalnim ventilatorom (Holder) koji se kretao brzinom 7.2 km/h. Prekriće je ocenjeno na 10 listova jabuke sorte Jonagold i na 10 testnih papira WSP (Water Sensitive Paper) postavljenih na vertikalnom ramu.

Ključne reči: *voćarski zasadi, pesticidi, raspršivači, prekriće, VarioWindSelect system.*