Spray coverage in wheat as affected by nozzle type, driving velocity and spray volume

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OBJECTIVES

Evaluation of spray coverage on vertical and horizontal surfaces of water sensitive paper collectors, placed at the ear and leaf F3 levels of wheat canopy in the head emergence stage, after spray treatments with different air-induction LECHLER nozzles, performed at three driving velocities and two spray volumes.

1. TREATMENTS

No.	Driving velociy *km/h*	Nozzles	Pressure *bar*	Flow rate *l/min*	Spray volume *l/ha*
1	8,0 NORMAL	 ID 03	5,0	1,53	**230**
2		 *IDTA 03*	5,0		
3		 *IDKT 04*	2,8		
4	12,0 FAST	 ID 03	5,0	1,55	**155**
5		 *IDTA 03*	5,0		
6		 *IDKT 04*	2,8		
7	16,0 VERY FAST	 ID 04	5,0	2,07	**155**
8		 *IDTA 04*	5,0		
9		 ID 05	7,1	3,07	**230**
10		 *IDTA 05*	7,1		

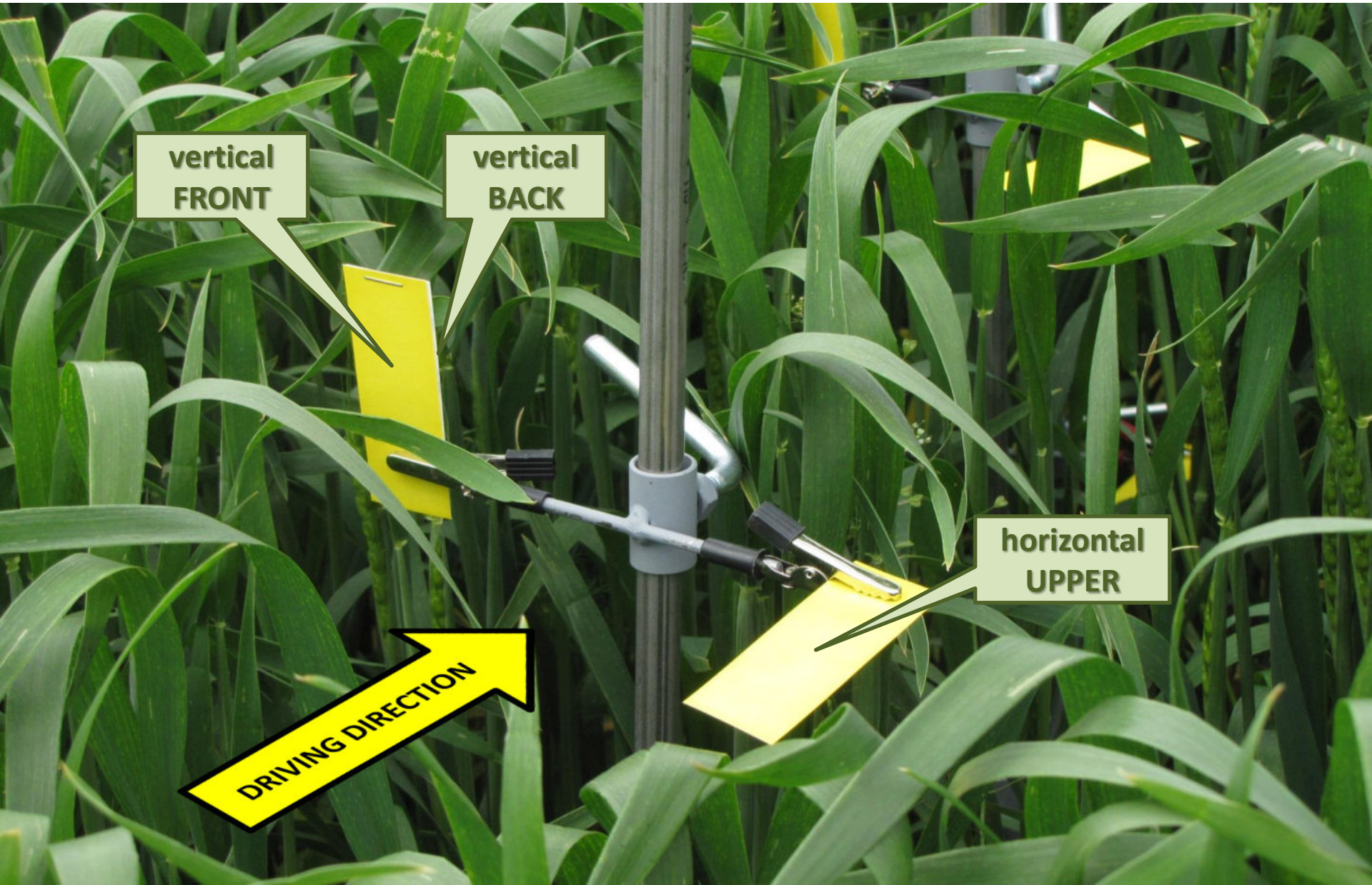
2. CROP: WINTER WHEAT

Canopy height:
80 cm

Growth stage: head emergence
BBCH 58 - 80% of inflorescence emerged

3. SAMPLE LAYOUT

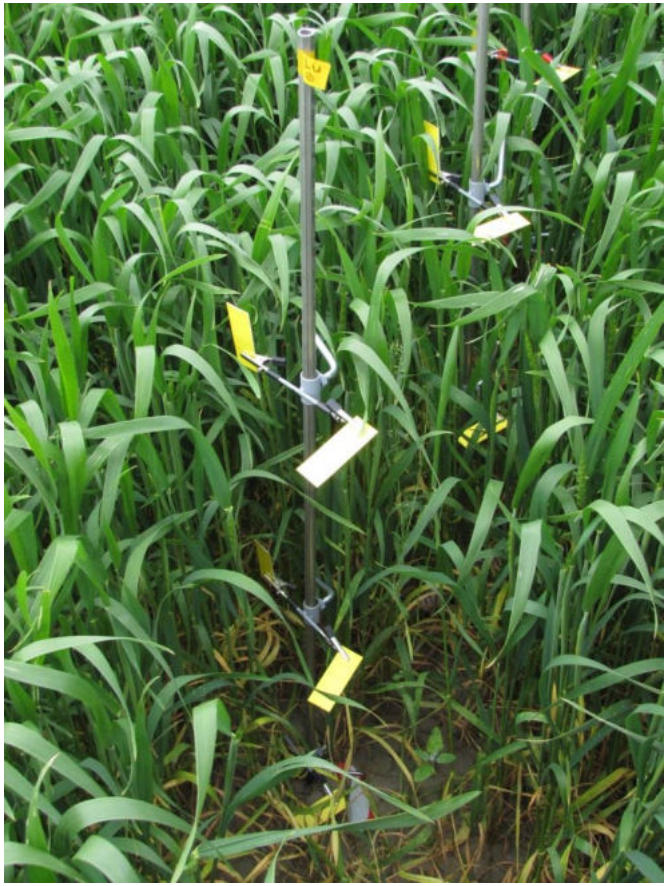
Water sensitive paper (WSP) collectors: vertical FRONT and BACK; horizontal UPPER

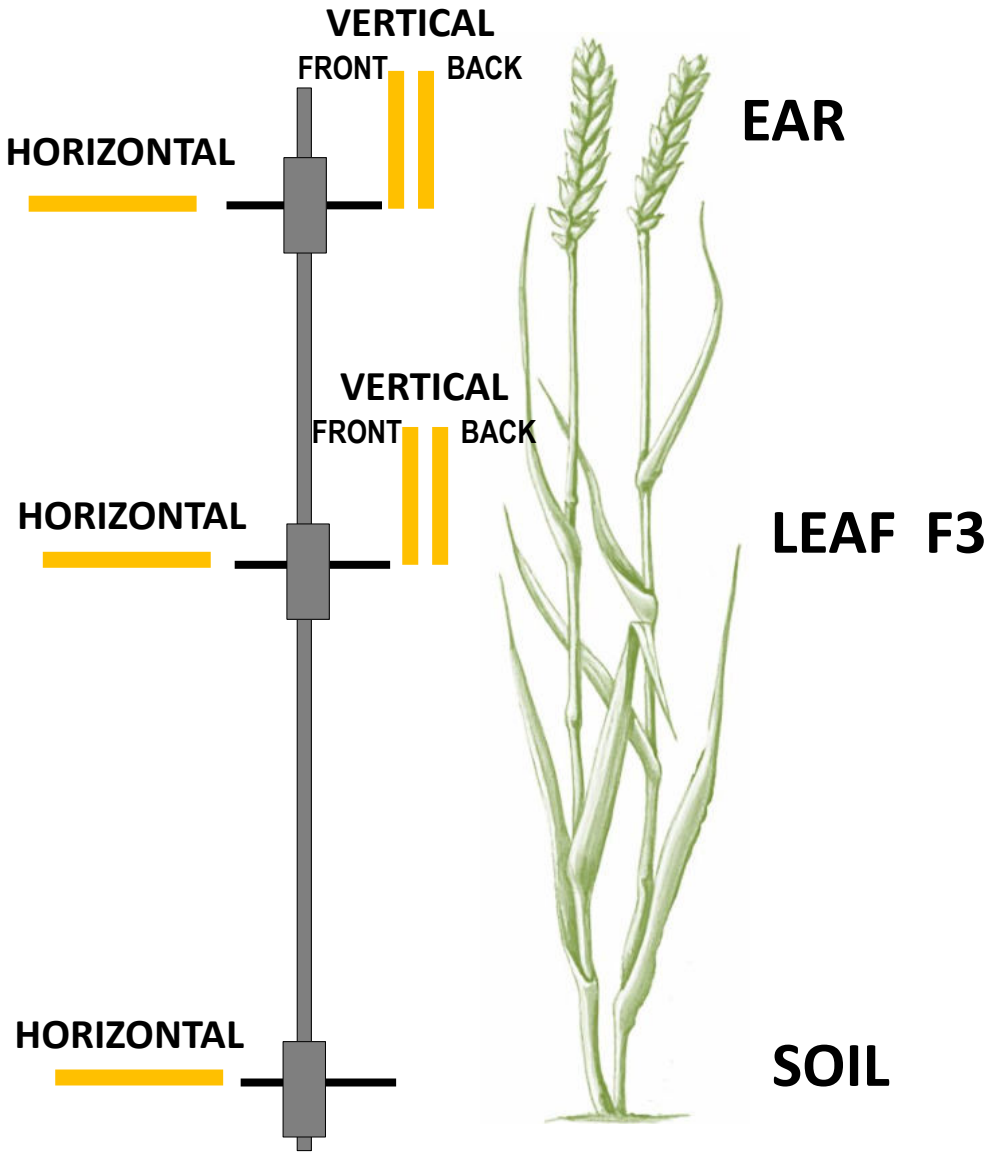


3. SAMPLE LAYOUT

Side view of three sampling levels in the crop canopy:

- canopy levels: EAR; LEAF F3; SOIL

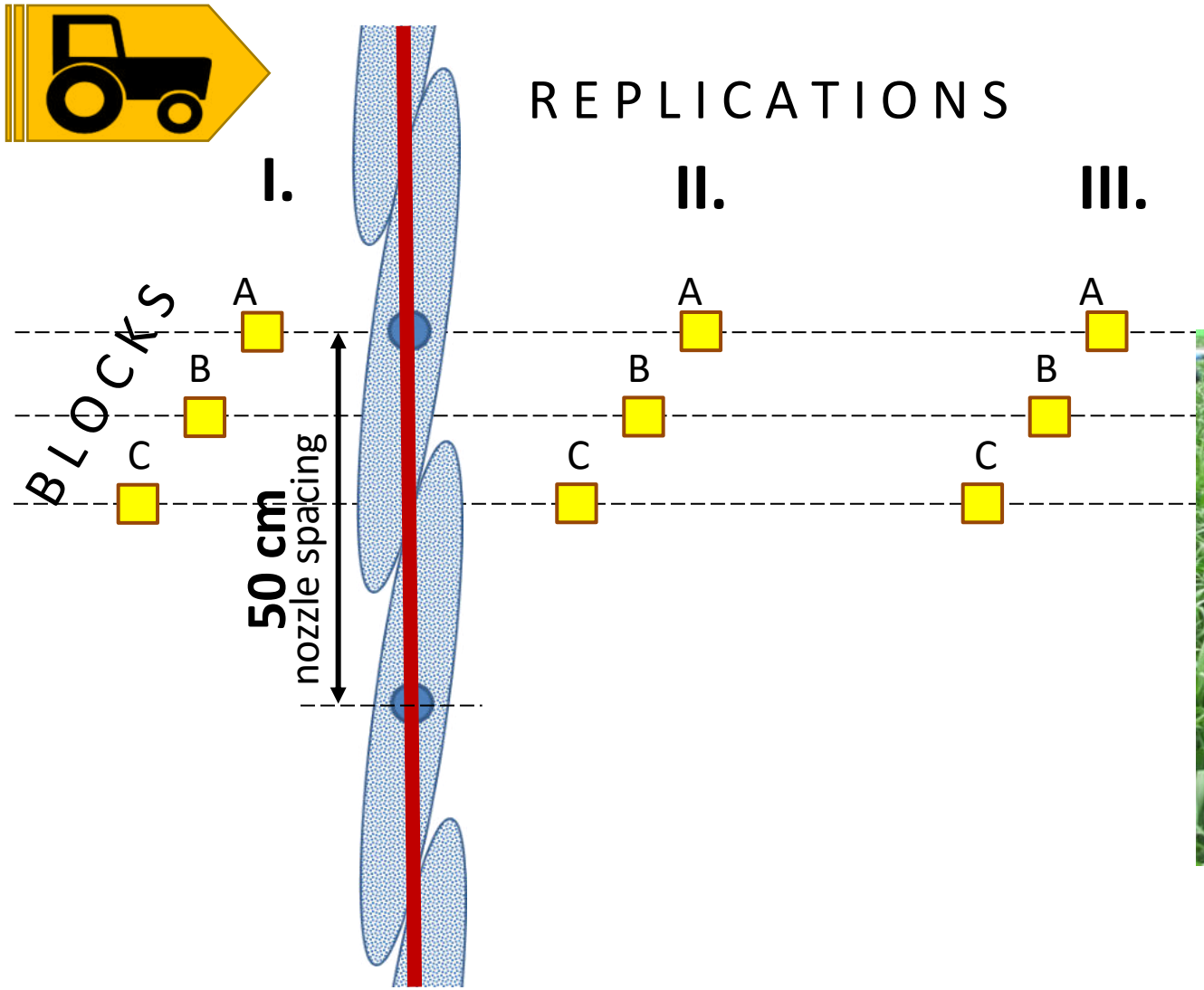


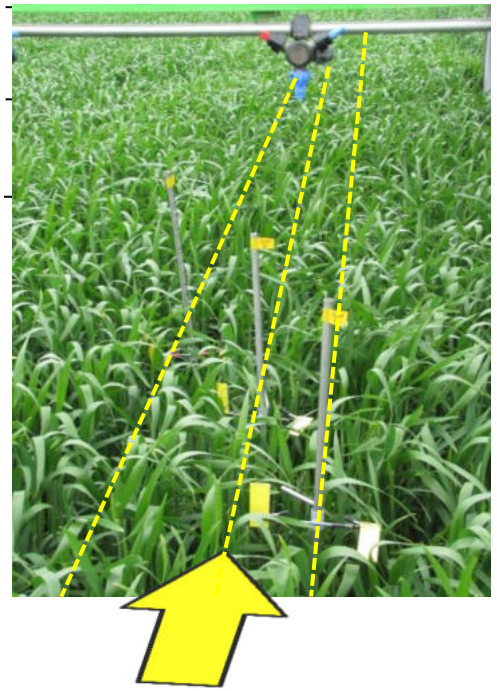


3. SAMPLE LAYOUT

Top view of nine sampling points in the crop canopy :

- three blocks across spray swath: A - jet centre; B - jet off-center; C - jet overlap
- three replications along sprayer passage



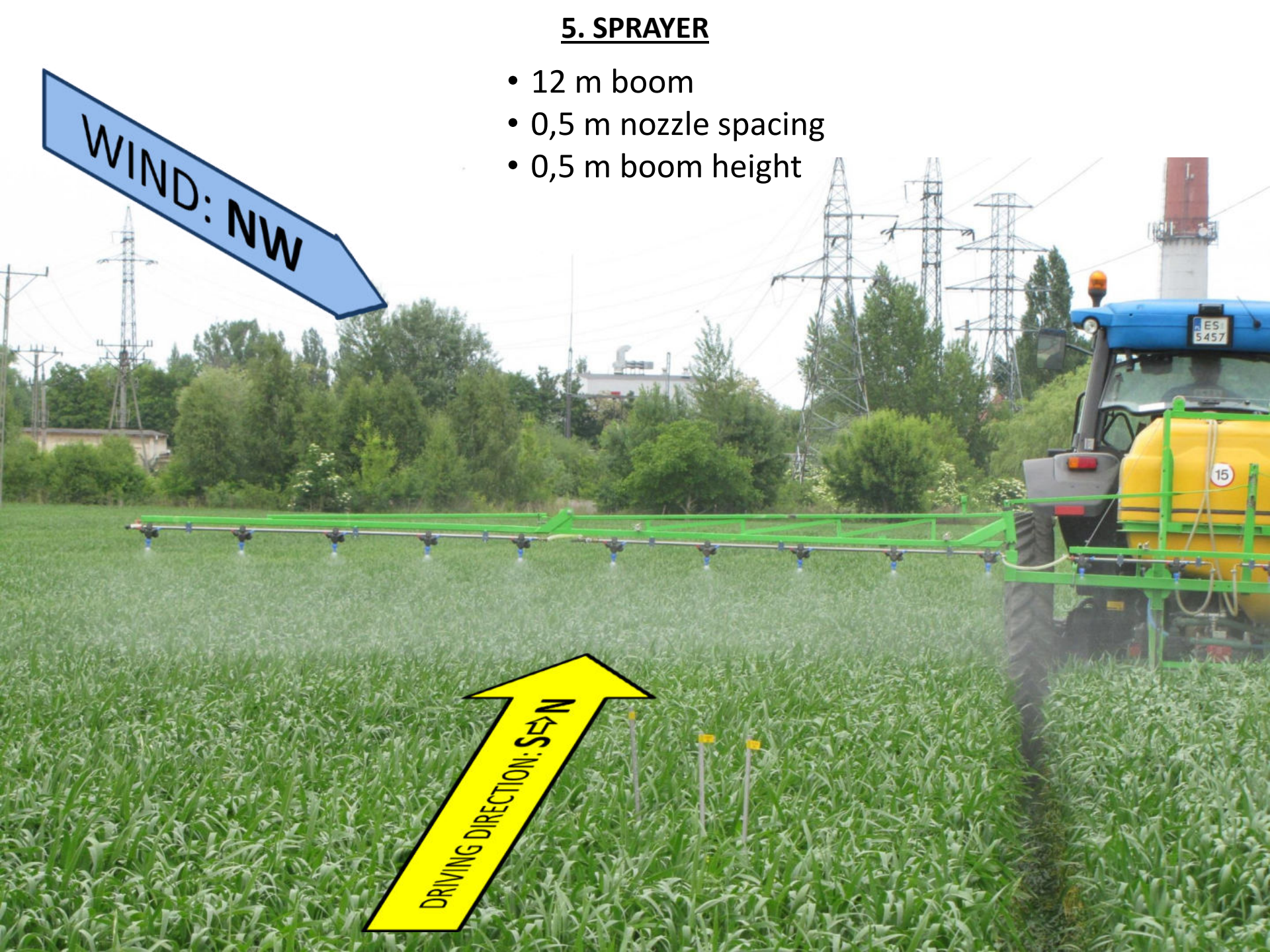


4. WEATHER CONDITIONS (15 June, 2015)

No.	Driving velociy km/h	Nozzles	Spray volume l/ha	Temp. °C	RH %	Wind vel. m/s	Wind dir. (driving SN)
1	8	 ID 03	230	15,5	51,6	2,0	NW
2		 IDTA 03		16,0	45,0	0,9	NW
3		 IDKT 04		18,5	43,8	2,6	NW
4	12	 ID 03	155	19,5	36,8	2,7	NW
5		 IDTA 03		22,0	34,9	3,1	NW
6		 IDKT 04		20,8	41,8	2,8	NW
7	16	 ID 04	155	19,5	38,2	2,6	NW
8		 IDTA 04		20,9	38,0	2,3	NW
9		 ID 05	230	19,9	40,8	2,5	NW
10		 IDTA 05		19,4	41,0	2,7	NW

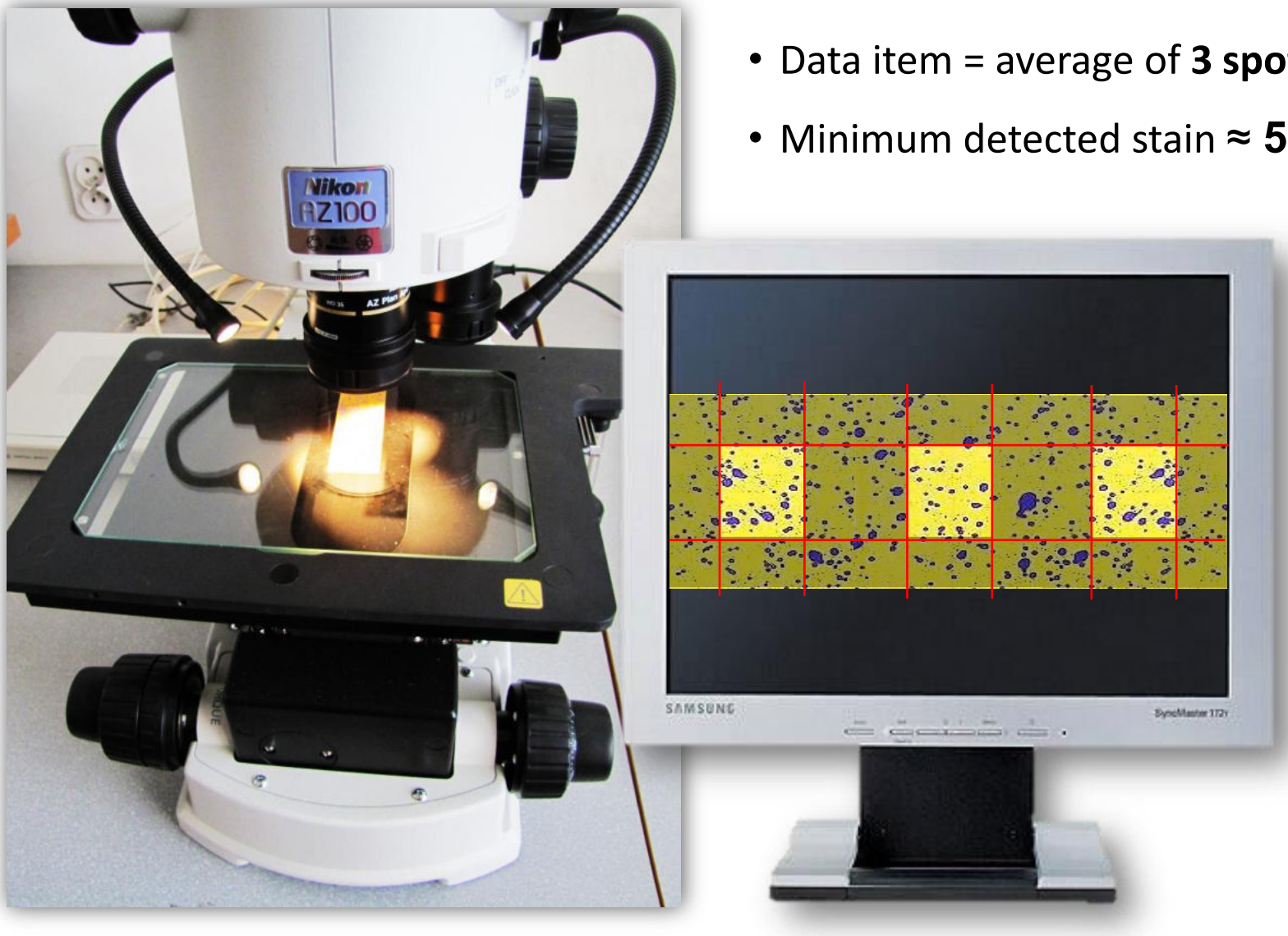
5. SPRAYER

- 12 m boom
- 0,5 m nozzle spacing
- 0,5 m boom height



6. LAB WORK

Image analysis of coverage on WSP – *Nikon AZ100*



- Data item = average of **3 spots 1 cm²**
- Minimum detected stain ≈ **50 µm**

During statistical data anaysis no significant differences, at $p \leq 0,05$, were found in coverage on EAR level (0,5 m boom height) between blocks A, B and C for any of the tested treatments, *ergo*:

1. for all nozzles/driving velocities/spray volumes the overlap of spray jets gave an uniform spray distribution across the spray swath at the crop level,
2. for the further analysis the blocks were considered replications,
3. with three replications across the spray swath and another three ones along the driving direction the total number of replications was nine,
4. the mean coverage % presented in the tables are average values of nine data items (replications),
5. each data item represents spray cover on a single specific WSP collector, calculated as an average value of three image analysis readings, each obtained over the spot of 1 cm^2 field of view; this small field of view allowed for detecting stains ~50 µm which also might contribute in coverage.

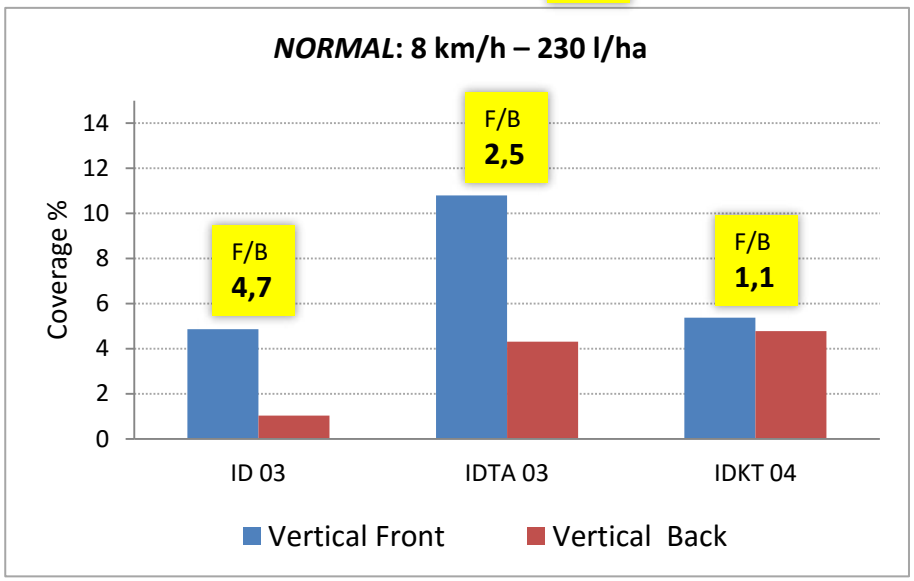
7. RESULTS: EAR

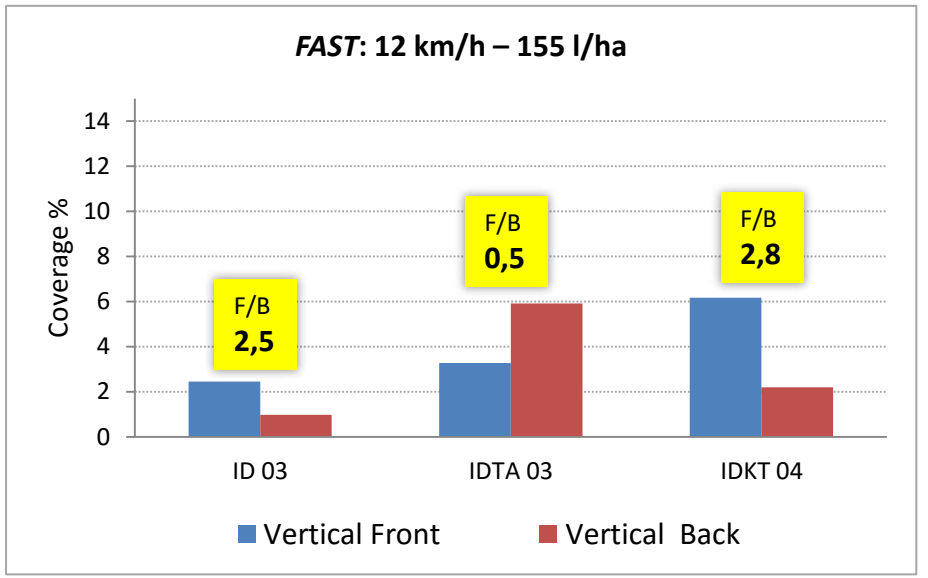
No.	Driving velociy km/h	Nozzles	Spray volume l/ha	Mean Coverage - EAR % Vert. FRONT	Vert. BACK	FRONT / BACK	Horizontal
1	8	 ID 03	230	4,87 bc	1,03 ab	4,73	22,25 d
2		 IDTA 03		10,80 d	4,31 c	2,51	26,93 e
3		 IDKT 04		5,38 c	4,78 cd	1,13	22,49 d
4	12	 ID 03	155	2,46 a	0,98 ab	2,51	14,31 a
5		 IDTA 03		3,28 ab	5,91 d	0,55	16,88 bc
6		 IDKT 04		6,17 c	2,20 b	2,80	18,68 c
7	16	 ID 04	155	3,12 ab	3,52 c	0,89	16,20 ab
8		 IDTA 04		6,19 c	8,54 e	0,72	23,04 d
9		 ID 05	230	9,09 d	0,68 a	13,37	23,90 d
10		 IDTA 05		13,82 e	5,79 d	2,39	29,33 f

7. RESULTS: EAR

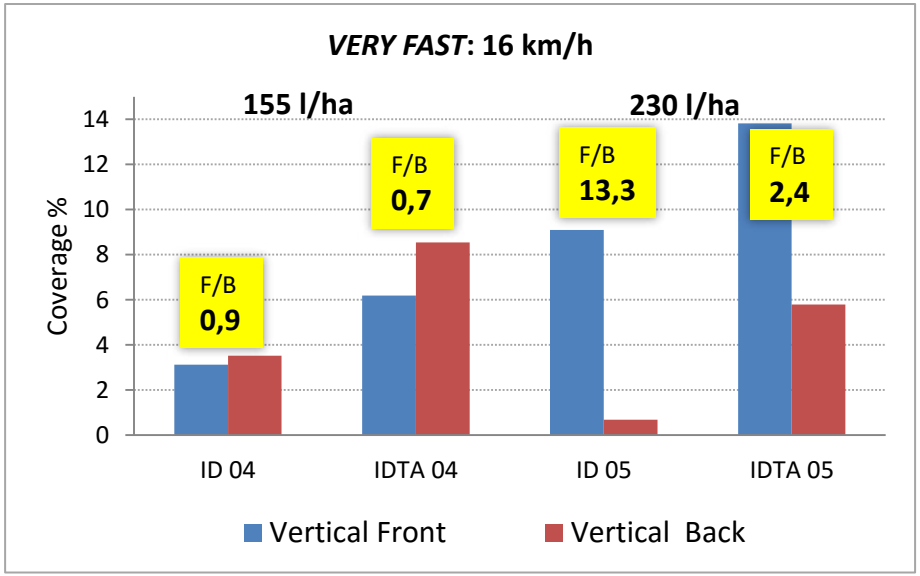
Uniformity: EAR level - Coverage % on vertical samples FRONT and BACK

F/B ratio: VERTICAL **FRONT** / VERTICAL **BACK**





- At the NORMAL velocity (8 km/h) the highest overall coverage on EAR level was obtained by IDTA nozzles, however the best coverage uniformity, very close to ideal, was achieved by IDKT ones (F/B = 1,1). In all cases the FRONT surfaces of vertical collectors were better covered than the BACK ones. The greatest difference was observed for ID nozzles (F/B = 4,7).
- The FAST velocity (12 km/h) substantially improved the coverage uniformity for ID nozzles (F/B = 2,5) and even reversed the F/B ratio for IDTA nozzles (F/B = 0,5), and considerably worsened the uniformity for IDKT nozzles (F/B = 2,8). In this treatment the best overall coverage and the best uniformity was obtained for IDTA nozzles.
- At the VERY FAST velocity IDTA nozzles proved their superiority over ID nozzles both for LOW (155 l/ha) and HIGH (230 l/ha) spray application rate. For the LOW rate they gave more than twice higher coverage on both FRONT and BACK collector surfaces and a similar F/B ratio (0,7 vs. 0,9) , with slightly better coverage on the BACK surfaces. For the HIGH rate the overall coverage remained much greater in favor of IDTA nozzles, and the difference in F/B ratio was highly contrasting (2,4 vs 13,3), in turn with much better coverage on the FRONT surfaces.



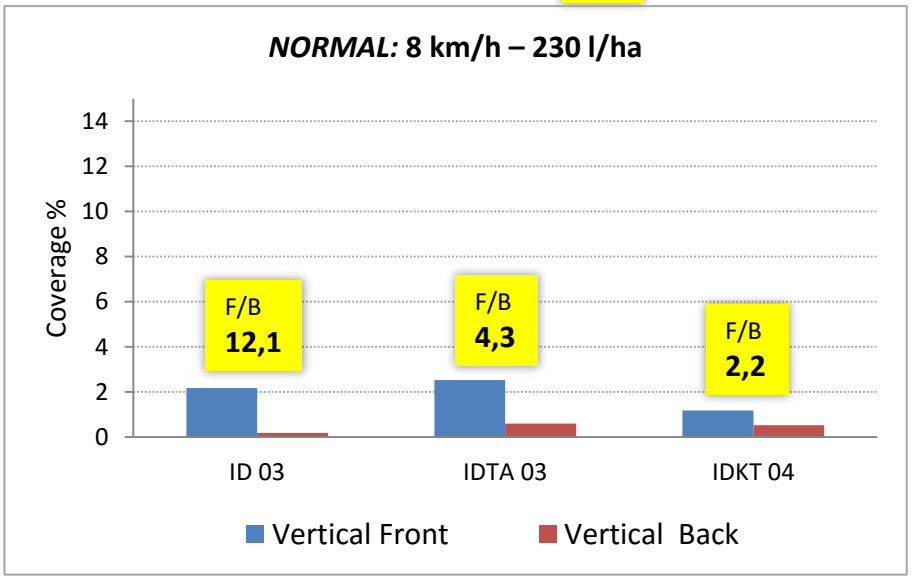
8. RESULTS: LEAF F3

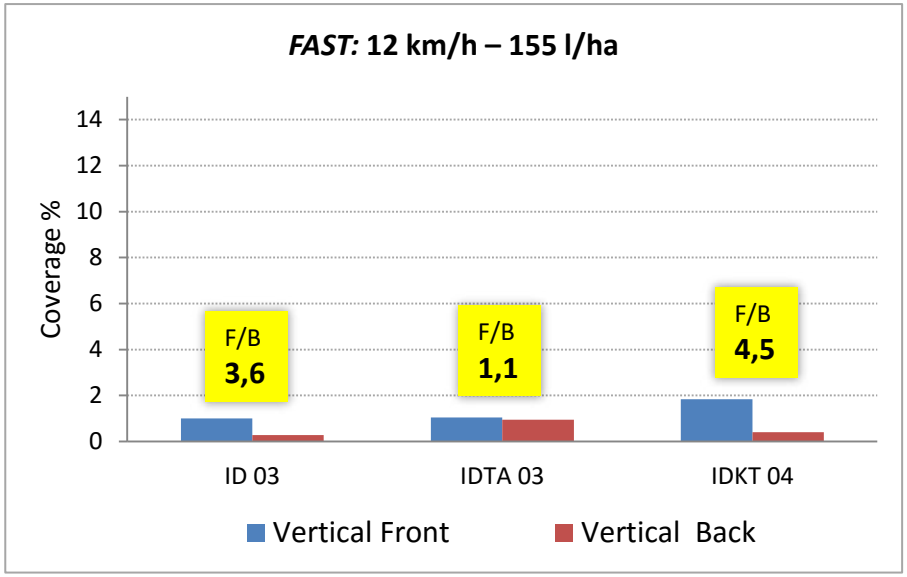
No.	Driving velociy km/h	Nozzles	Spray volume l/ha	Mean Coverage – LEAF F3 % Vert. FRONT	Vert. BACK	FRONT / BACK	Horizontal
1	8	 ID 03	230	2,17 ab	0,18 a	12,06	13,86 de
2		 IDTA 03		2,52 b	0,59 abc	4,27	14,98 ef
3		 IDKT 04		1,18 a	0,53 ab	2,23	12,22 cd
4	12	 ID 03	155	1,00 a	0,28 a	3,57	8,84 ab
5		 IDTA 03		1,05 a	0,95 c	1,11	7,52 a
6		 IDKT 04		1,84 ab	0,41 ab	4,49	9,91 bc
7	16	 ID 04	155	2,99 b	0,37 ab	8,08	11,15 bc
8		 IDTA 04		2,02 ab	0,73 bc	2,77	10,74 bc
9		 ID 05	230	4,78 c	0,24 a	19,92	16,82 f
10		 IDTA 05		4,20 c	0,60 abc	7,00	13,64 de

8. RESULTS: LEAF F3

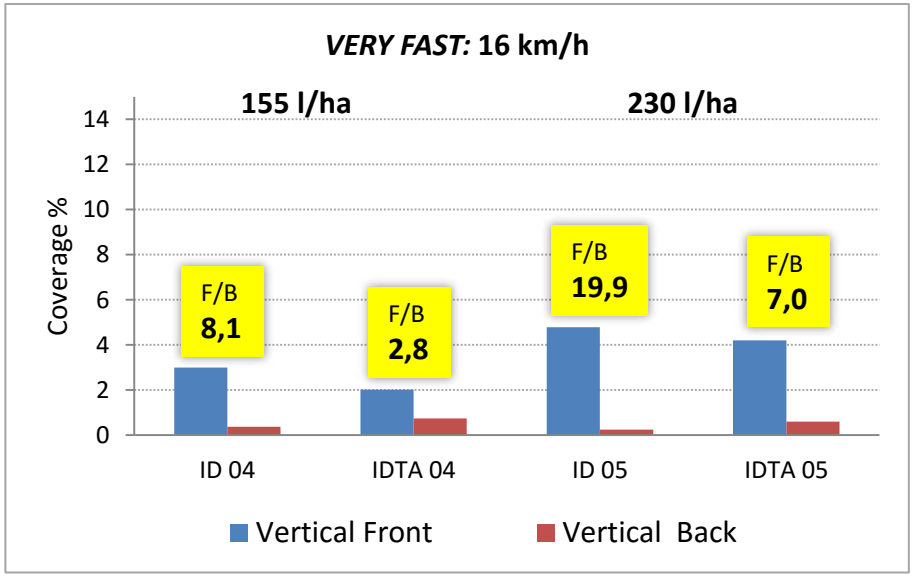
Uniformity: LEAF F3 level - Coverage % on vertical samples FRONT and BACK

F/B ratio: VERTICAL **FRONT** / VERTICAL **BACK**





- At the NORMAL velocity the coverage situation on the LEAF F3 level was a copy of trends observed on the EAR level. The coverage values, however were 2-5 times lower and the F/B ratios at least doubled. The overall coverage was highest for IDTA nozzles and the uniformity was best for IDKT ones. For ID nozzles the F/B ratio exceeded 12.
- At the FAST velocity the best overall coverage and almost ideal uniformity (F/B = 1,1) on the LEAF F3 level was obtained by IDTA nozzles. The 50% increase of velocity improved coverage uniformity for ID nozzles and worsened the F/B ratio for IDKT ones.
- At the VERY FAST velocity no significant differences between ID and IDTA nozzles were observed in coverage on either surface and within either spray volume rate. The F/B ratio, however was always better (nearly three times lower) for IDTA nozzles reflecting better uniformity obtained.



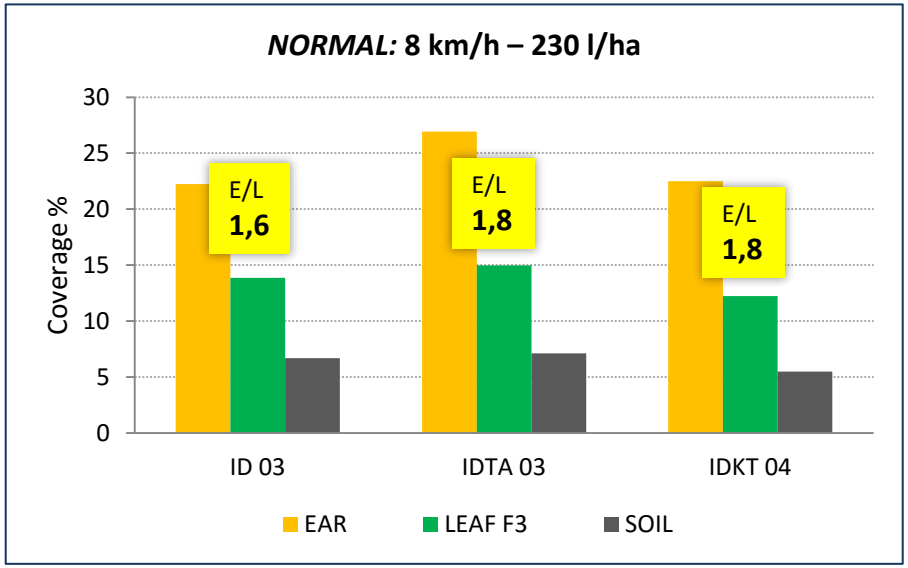
9. RESULTS: PLANTS and SOIL

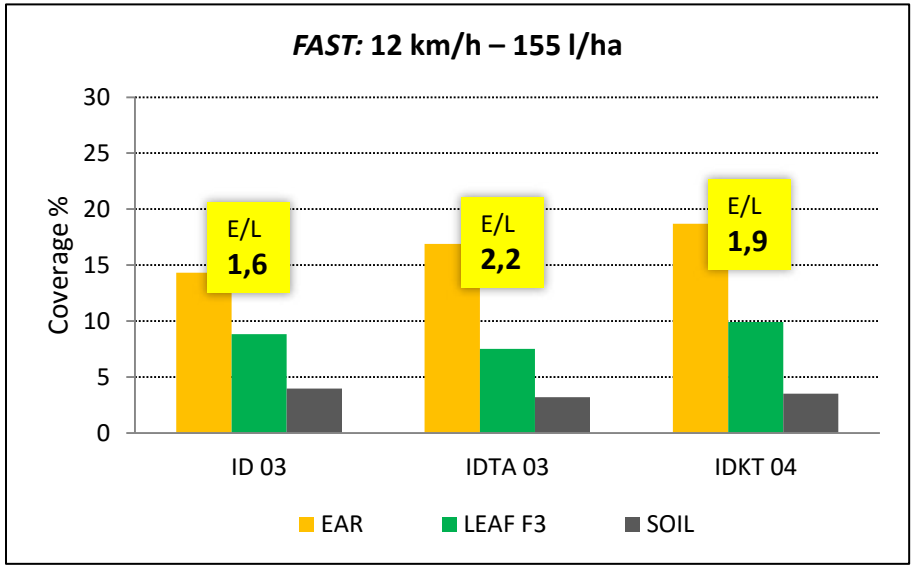
No.	Driving velociy km/h	Nozzles	Spray volume l/ha	Mean Coverage % PLANTS	Hor. EAR / Hor. LEAF F3	SOIL
1	8	 ID 03	230	7.39 bc	1,61	6,68 de
2		 IDTA 03		10.02 de	1,80	7,11 e
3		 IDKT 04		7.76 bc	1,84	5,49 cde
4	12	 ID 03	155	4.64 a	1,62	3,96 abc
5		 IDTA 03		5.93 ab	2,24	3,19 b
6		 IDKT 04		6.54 ab	1,88	3,50 bc
7	16	 ID 04	155	6.22 ab	1,45	5,18 bcd
8		 IDTA 04		8.54 c	2,15	3,18 a
9		 ID 05	230	9.25 cd	1,42	5,14 bcd
10		 IDTA 05		11.23 e	2,15	4,36 abc

9. RESULTS: PLANTS and SOIL

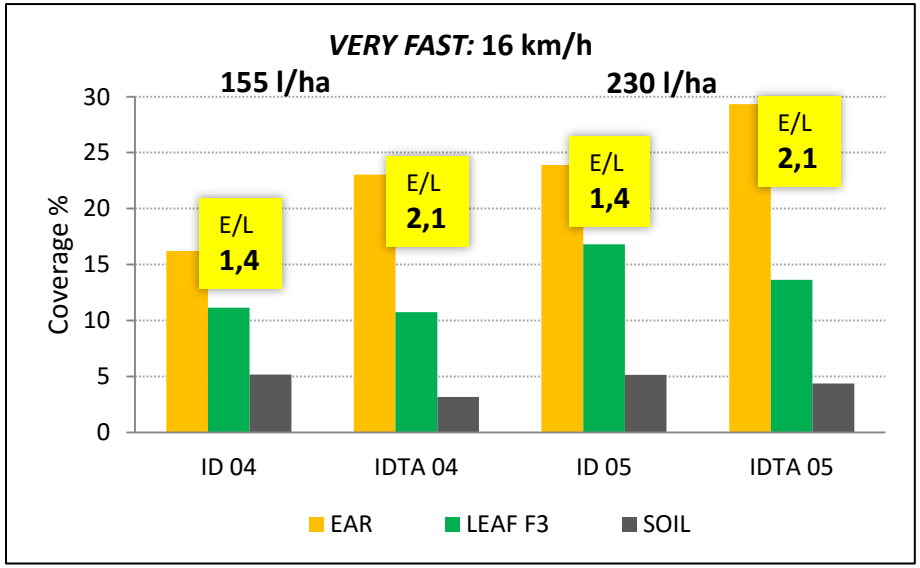
Penetration: EAR ⇨ LEAF F3 ⇨ SOIL - Coverage % on horizontal samples

E/L ratio: HORIZONTAL **EAR** / HORIZONTAL **LEAF F3**





- At the NORMAL velocity IDTA nozzles produced the highest coverage on horizontal collectors on both EAR and LEAF F3 levels, and not significantly different from other nozzles on the SOIL. The penetration expressed by E/L ratio was similar for all tested nozzles, with the lowest value for ID ones.
- At the FAST velocity the vertical spray jet of coarse droplets from ID nozzles ensured sustaining relatively good penetration, while that for twin jet nozzles was slightly worsened. Nevertheless the coverage on both EAR and LEAF F3 levels was highest for IDKT nozzle. The SOIL contamination was at the same level for all the tested nozzles.
- At the VERY FAST velocity the superior penetration of ID nozzles over IDTA nozzles was confirmed again. This in-depth canopy penetration, however resulted in higher soil contamination, especially at LOW spray application rate. At both rates the coverage on horizontal collectors on EAR level was significantly higher for IDTA nozzles than for ID ones.



10. CONCLUSIONS

- The IDKT nozzles showed the best performance in terms of coverage and uniformity at NORMAL driving velocities.
- At the increased velocity IDTA nozzles proved to be superior over both IDKT and ID nozzles
- ID nozzles showed the best penetration into the crop canopy both at NORMAL and increased velocities.

- The twin-jet nozzles should be especially recommended for the treatments T3 (control of diseases on ears and flag leaves from the head emergence to the anthesis stage, BBCH 51-75) when good spray coverage and uniformity is required at the upper levels of he crop canopy:
  - IDKT – at NORMAL velocity
  - IDTA – at velocities higher than 8-10 km/h

- The ID nozzles should be especially recommended for treatments where the in-depth penetration is required, eg. control of diseases and pests feeding at the base of stalk or weed killing before harvest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