STUDY ON DETERMINING THE DEGREE OF COVERAGE WHEN PERFORMING PHYTOSANITARY TREATMENTS USING WATER SENSITIVE PAPER

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Abstract

Increased coverage when spraying, especially using contact substances, leads to higher efficiency and crops. Conventional nozzles, where the droplets move parallel to the stem of the plant ensures a good covering of the horizontal and inclined parts of plants, the vertical parts (strain) the deposit of the solution particles is lower and thus the coverage is inadequate. The main goal of this paper was to determine and to evaluate the coverage degree for 4 types of nozzles and for the Gamberini 500 orchard spraying machine. Experimental tests conducted with two types of nozzles aimed the coverage assessment of horizontal and vertical parts of the plant using conventional and double jet nozzles. Evaluation of coverage was made using water sensitive paper and the MATHCAD program, which determines the area covered. For the purpose of this paper, the machine Gamberini 500 was used in laboratory conditions to determine and evaluate the coverage degree. This spraying machine is a pneumatic one, with a special boom. In order to evaluate the degree of coverage, a special paper was used, which was placed at different heights (1; 2; 3m)

Key words: coverage, spraying machine, MATHCAD, water sensitive paper, pneumatic distribution

Today, the most common plant protection measure is the application of chemical plant protection products by using air-assisted sprayers. Pesticides are widely used to control pests and diseases of food crops, which may lead to residues in foodstuffs.

It is known that, in addition to proper plant protection substances, strict adherence to the period of their application, machines and equipment for plant protection or spray quality can influence decisively the effectiveness of phytosanitary treatments.

Weeds, diseases and pests control under field conditions requires correlating mechanical (machine), organizational and methodological factors. The control effect is optimal only when it ensures uniform coverage of plants with pesticides and drift and evaporation losses are minimal.

Improvement of spraying machines is a permanent issue for building factories and it covers not only the automation of operations by introducing electronics, but also ensure adequate spray thus to ensure the best possible coverage of all parts of the plant.

It is known that dicotyledonous have broad-leaved arranged horizontally, which allows for better retention of the drops, as opposed to the monocotyledonous grasses, in particular, with narrow leaves, upright stem and thus intercept and retain less solution, particularly when the jet is perpendicular to the ground.

In vineyards and orchards, pesticide treatments are of great importance in particular as the intensive culture usually takes more than two treatments. If one wants to obtain a good coverage, the spraying machine must function within the parameters and to have all the settings adapted for the wind condition and the plants. Because in orchards and vineyards the machine is moving on the interval between plants and is spraying the entire surface, it is difficult to have a high coverage especially at the top.

The main objectives of this paper was to determine the coverage of plants with drops of solution using different types of nozzles for crop fields and to determine the coverage degree og the GAMBERINI 500 orchard sprayer. The nozzles were made by four important firms in the field. The GAMBERINI 500 spraying machine is a low volume sprayer. It can deliver an amount of 40 to 500 litres per hectare, thus making the fruits less sprayed. In order to test this machine, we have set up an experiment to determine the coverage degree in laboratory conditions.

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MATERIAL AND METHOD

For experimental tests the aggregate used was U-683 tractor unit and the EEP-600M [1] implement, a spraying machine which corresponds to European standards required. The spraying machine was equipped on all four types of nozzles, with different technical data, but with the same flow.

The nozzle D1 is a plastic conventional nozzle with a lenticular spray pattern, manufactured by LECHLER, 120-04 LU type.

D2 nozzle is made by the same company LECHLER, with a symmetrical double-jet pattern, type DF, 120-04, made of stainless steel.

Nozzle D3 is AGROTOP High-speed TD-110-04 type, with double asymmetric jet pattern used for treatments at high speed. The angle of the jet is greater at the back (50°) and lower in the front (10°).

The nozzle D4 is TTJ-type 110-04, double symmetrical jet nozzle made of plastic material, with the angle of the jets 15°.

All the four nozzles were at the same pressure and the same flow rate that is 1.5 l / min at a pressure of 2.8 bar. During experimental tests worked 3 bar pressure, resulting in a flow rate of 1.6 litters / min.

In order to determine the degree of coverage in horizontal and vertical planes were manufactured mounts. Water sensitive paper was pasted horizontally and vertically at the front and at the back.

Before each test the distance between boom and paper holder was adjusted to the height of 50 cm, the working speed was 10.8 km / h, to provide a rate of 200 l / ha.

For each type of nozzle three repetitions were made.

After experimental tests, samples of water sensitive paper prints were scanned and then using a program MATHCAD [2] which assesses the area covered, the coverage could be estimated.

In order to determine the coverage degree for an orchard spraying machine, the tractor U683 DT and the machine Gamberini 500 was used in laboratory conditions. This spraying machine is a pneumatic one, with a special boom.

In order to determine the degree of coverage, the following setup was used:

1. The flow calibration plate was set to the 3rd division;
2. The power-take-off was set to 540 RPM (2000 RPM engine crankshaft);
3. The pressure was adjusted to 2 bar using the pressure calibration knob;
4. The flow rate of the machine was determined by means of collecting the solution delivered by the both sides for 30 seconds – 5,2 l/min;
5. The working speed was determined using the BRAVO 300 computer – 4 km/h.

All these settings were made in order to achieve a quantity of 200 litres per hectare.

After setting up the machine, the water sensitive paper was place on two steel rods

Each piece of Water Sensitive Paper (WSP) was cut to the following dimensions 10cm x 2,5 cm and was placed with respect to the traveling direction of the aggregate in front (against the traveling direction), centred (perpendicular onto the traveling direction) and rear (opposite to the traveling direction).

The WSP was placed at 1 meter, 2 meters and 3 meters (fig. 2, C). Every paper was given a code: L- left, R- right; F- front (for L code and R code, the height was specified: 1-1 m; 2- 2 m; 3- 3m), C- centre, R- rear; R- repetition (1, 2, 3). The experiment was repeated three times.

After the aggregate passed, the WSP paper was scanned at a resolution of 300 DPI. The scanner used was CanoScan 5600F. The WSP`s were scanned in black and white.

The scanned image was than cropped to a specific dimension (9.8 cm x 2.3 cm) to exclude the influence of the margins.

All the cropped images were inserted in the MATHCAD program. For all the 36 WSP`s the command READBMP was used resulting the correspondent matrix.

MRF1R1 = READBMP(“E:\gamberini\RF1R1)

This command (READBMP) reads the pixels inside the image and attribute them a value. Being scanned black and white, the command attributes the value 255 for the white colour and 0 for the black colour. This result cannot be processed so the next step was to change the values for colours, using the relation 2.

$$MRF1R1=1-MRF1R1/255$$

The relation changes values and assigns the value 0 for white colour and 1 for black colour. The reason why we've made these changes is that the drop of solution reaching the WSP change its colour. So now we can map every single drop that was on the WSP. An example of these transformations is presented in *figure 1*.

The next step was to extract from these matrixes equal sub matrixes in order to calculate the coverage. This extraction was made using the following relation.

MRF1R1=submatrix(MRF1R1, 0, 1000,0,230)

After this extraction, the resulted matrix had 230 columns and 1100 rows.

In order to calculate the covered area of the WSP a formula was inserted which summarize the colons and rows and multiplies it to the surface of a pixel (7,17*10-9 m^2)

The coverage degree was calculated using the formula:

$$GaMRF1R1=SMRF1R1*100/Spr$$
$$Spr=2.5*9.5*10\text{-}4\ [m^2]$$

	0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	255	0	0	0	0	0	0	0	255	255
6	0	255	0	0	0	255	0	0	255	255
7	0	0	255	255	255	255	0	0	0	255
8	0	0	255	255	255	255	0	0	0	0
9	0	0	0	0	255	255	0	0	0	0
10	0	0	0	0	255	0	0	255	0	0
11	0	0	0	0	0	0	255	255	0	0
12	0	0	0	0	0	0	255	255	255	0
13	0	0	0	0	0	255	255	255	255	0
14	0	0	0	0	0	255	255	255	255	255
15	255	255	255	255	255	255	255	0	0	...

A

	48	49	50	51	52	53	54	55	56	57
827	1	1	1	1	1	1	1	1	1	0
828	1	1	1	1	1	1	1	1	1	1
829	1	1	1	1	1	1	1	1	1	1
830	1	1	1	1	1	1	1	1	0	1
831	1	1	1	1	0	0	0	0	0	0
832	0	0	1	0	0	0	0	0	0	0
833	1	0	0	0	0	0	0	0	0	0
834	1	0	0	0	0	0	0	0	0	0
835	0	0	0	0	0	0	0	0	0	0
836	0	0	0	0	1	1	0	0	0	0
837	0	0	0	0	1	1	1	0	0	0
838	0	0	0	0	0	1	1	0	0	0
839	0	0	0	0	0	1	1	1	0	0
840	1	1	0	0	1	1	1	1	0	1
841	1	1	1	1	1	1	1	1	1	1
842	1	1	0	1	1	1	1	1	1	...

B

Figure 1 **Matrix of value before and after the transformations**
A- **The matrix of values before transformations (0- black colour; 255- white colour); B- the matrix of values after transformation (0- white colour; 1- black colour)**

RESULTS AND DISCUSSIONS

The samples scanned for the four nozzles are shown in the *figure 2a* and coverage provided after evaluation using MATHCAD program are listed in *figure 2b*.

From image analysis in *table 1* and the data in *figure 3* can be seen following:

- nozzle D1, the conventional one, with a classic lenticular pattern achieved good coverage of the horizontal part (51.2%) and especially the vertical posterior side had a lower degree of coverage (2.09%);
- nozzle number 2 has double symmetrically jet and a greater angle between the two jets. It provides very good coverage in the horizontal (52.28%) and the vertical plane (49.64%), but lower on the vertical back (4.27%);
- nozzle D3 has asymmetric double jet, higher angle at the back. It provides the best coverage of all the nozzles at the rear vertical (6.25%) due to higher angle, but the front vertical and horizontal coverage is less than symmetric jet nozzle D2;
- nozzle number 4 is a symmetric double jet nozzle, lower angle between jets ensure good coverage of the horizontal and vertical front plane (36.02% and 29.22%), but on the rear upright provides the lowest coverage of all the nozzles (1.71%).

To highlight the coverage achieved by the four types of nozzles a graph was done in *figure 2b*.

For the Gamberini 500 spraying machine the degree of coverage was calculated in the same way.

It can be observed from *figure 3* that the on the inner part of the row the coverage degree is larger. The smallest coverage was noticed on the rear side of the row with respect to the movement of the machine. At 1 meter from ground, the inner part registered a coverage degree of 25.11%, almost double than the front side. The rear side registered only 0.41 % coverage. At 2 m height, the biggest coverage degree was obtained on the left side of the machine (42.17%) almost double than the right side. This is a fact that can be explained in relation to the wind speed. When the machine passed between the steel rods, there was a small wind blast. At 3 m from ground the trend ins maintained. The inner part of the row , both right and left registered the biggest values of coverage. The left side had a degree of coverage smaller than the right side almost by 10%.

Overall the coverage degree was higher within the row (inner part) and smaller on the rear part. The front side had a degree of coverage between 13.3 % at 1 m and 23.59% at 3 m. for the right side. For the left side, the coverage degree was comprised between 6.2% at 2 m and 25.47% at 1 m. This fluctuation can also be attributed to the wind conditions.

The rear side bot right and left registered the smallest values of coverage degree. The values registered were comprised between 0.41 and 0.97% for the right side and 0.42 and 2.28% for the left side.

As mentioned before there was a disturbance in the determination of the coverage degree for the height of 2 m on the left side.

The fact that the front side registered a value inferior to other determinations (6.2%), the inner part registered the highest value (42.17%) and the rear side registered the higher value (2.28%) make us believe that was a small burst of wind opposite to the movement of the machine which transported a higher amount of water on the rear side and on the front side a small amount of water reached the target.

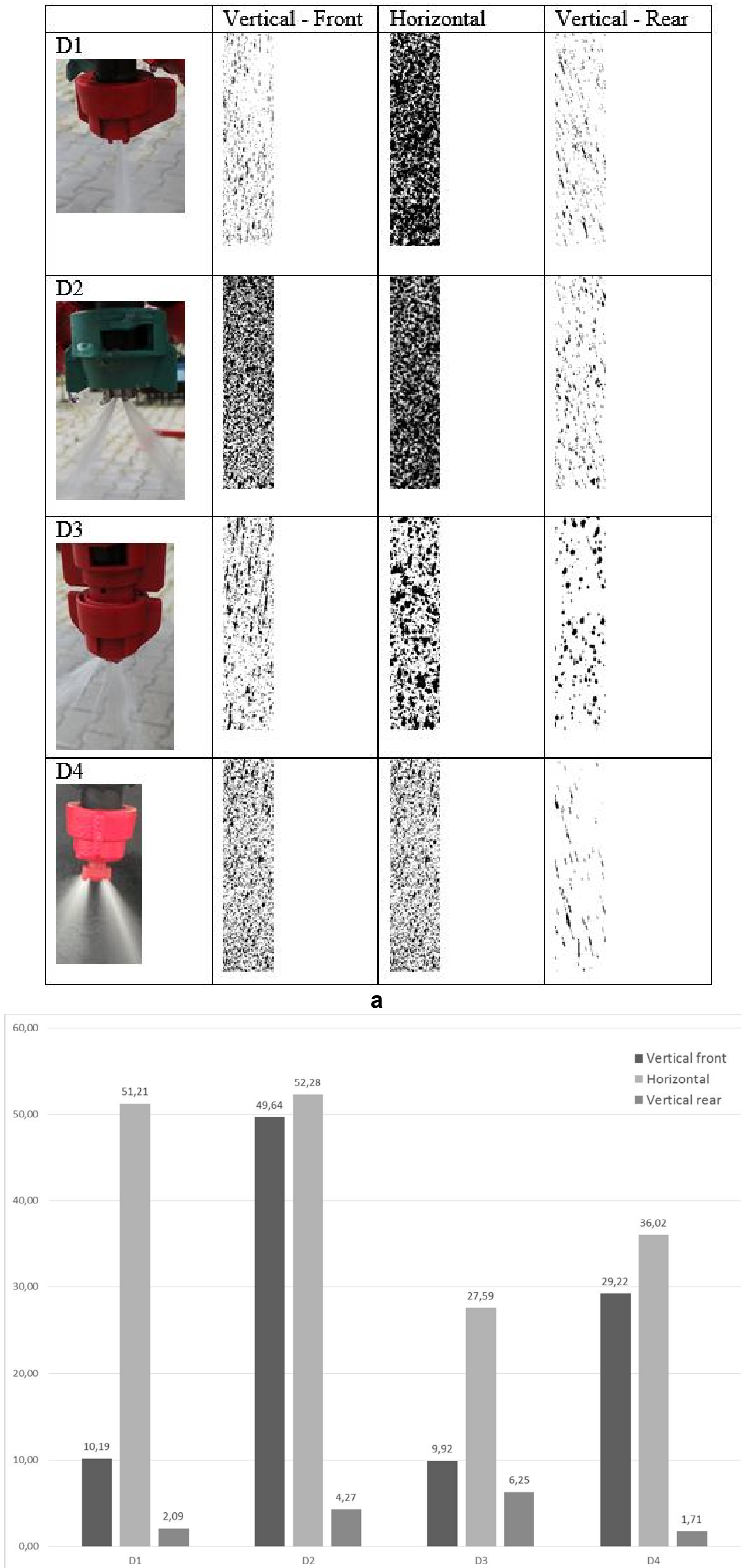

Figure 2 **Evaluation of coverage degree for 4 nozzles**
a - Water sensitive prints after scan; b - evaluation of coverage degree

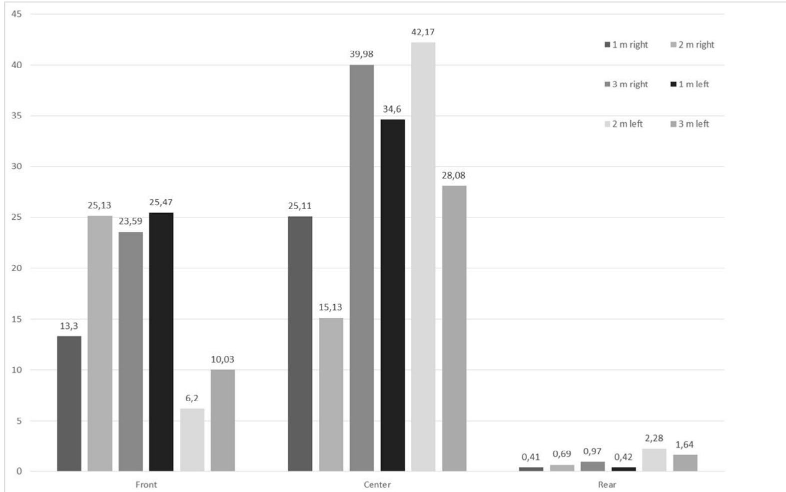

Figure 3 **Evaluation of coverage degree for Gamberini 500 spraying machine using WSP and MathCad**

CONCLUSIONS

Analysing data and charts resulting from experimental tests, the following conclusions can be drawn:

- to ensure good coverage, the type of nozzle will take into account the morphology of the plant, meaning that plants with several parts placed upright and narrow leaves (monocots) will be better covered by solution using double-jet nozzles. For broad-leafed plants, located horizontally or inclined, the jet nozzles may be used simply perpendicular to the ground;
- the best coverage vertical and horizontal, is achieved using the double jet 120-04 DF-symmetrical ;
- on the vertical plane in the rear, nozzle TD-110-04 provides the best coverage;
- simple jet nozzles and double jet with smaller angle between jets, had the best coverage for the vertical posterior plane.

Regarding the methodology of coverage determination, the WSP paper is a fast way to determine the area covered. Using a MathCad program it is possible to determine a more precise area covered by droplets.

The Gamberini 500 machine has an overall good coverage taking into account that it is a machine used for low volumes (can deliver 40 L /hectare). The rear side of the machine had the smallest coverage degree, but this is improved when the machines turns and moves on the adjacent row.

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