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ISSN 1330-7142
UDK = 631.348.45:634.11

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Original scientific paper
Izvorni znanstveni članak

SUMMARY

Three commercial mist-blowers were tested in an apple orchard at the end of vegetation development in October 2008, using pure water and water sensitive papers (WSP). The width between apples rows was 3.5 m, the average width of tree top was 1.6 m and the average apple height was 3.6 m. All the machines had the same "Albuz ATR 80" red nozzles and the tractor's PTO had a rotational speed of 540 rpm. The average temperature during testing was 17.05 °C; the average air humidity was 56.55 %, and the average wind speed was 0.9 m/s from the West. The spraying equipment used was: (A) "Tifone Vento" 1500, water levels of 1000 l/ha, maximum. air velocity of 30 m/s and 18638 m^3/h of airflow, 14 nozzles, travel velocity of 5 km/h and work pressure of 17 bars; (B) "Myers N1500", water level of 1000 l/ha, maximum. air velocity of 34 m/s and 36580 m^3/h of airflow, 14 nozzles, travel velocity of 5 km/h and work pressure bar of 11 bar; (C) "Hardi Zaturn 1500", water level of 1000 l/ha, maximum. Air velocity of 38 m/s and 44590 m^3/h of airflow, 18 nozzles, travel velocity of 5 km/h and work pressure of 7 bar. The "Tifone" mistblower had 10048 m^3/h total amount of air on the left side of the blower and 8590 m^3/h on the right side. With this amount of air, the average WSP coverage on the left side was 44.05 %, and on the right was 41.33 %. The"Myers" mistblower had 18120 m^3/h total amount of air on the left side of the blower and 18460 m^3/h at the right side. With this amount of air, the average WSP coverage on the left side was 33.61 %, and on the right side was 37.98 %. (C) The "Hardi" mistblower had 24940 m^3/h total amount of air on the left side of the blower and 19650 m^3/h on the right side. With this amount of air, the average WSP coverage on the left side was 45.85 %, and on the right side was 42.47 %.

The WSP were photographed by a "Canon EOS 1000D". The pictures were then converted by "Irfan View 4.0", and finally elaborated by "Adobe Photoshop", "Global Lab Image/2" and "Graduate" softwares.

Key-words: mist-blower, water sensitive paper (WSP) coverage, airflow, apple orchard, air velocity

INTRODUCTION

Today, in modern agriculture, crop protection is a very important thing. Many orchards can have significant damage if protection isn't sufficient. The greatest problems are caused by incorrect spraying equipment with irregular leaf coverage. Many of the mistblowers in our fields are out of date, and they can't adequately cover the treated area. In addition, the basic parameters of the mistblowers are not properly fitted. Together, these problems cause the degradation of orchards and the expansion of diseases. Therefore, our major task is to set optimal parameters for the exploitation of these mistblowers and for the adequate coverage of leaves. In order to have a good leaf coverage in orchards

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many factors such as the timing of the application, choice of spray formulation, type of equipment and its calibration must be considered. The sprayer should uniformly deposit material on the canopy tree, with a minimum of off-target loss (Derksen and Gray, 1995). Uneven distribution on the foliage and high drift losses may lead to inadequate pest control, which may then require repeated applications; additional treatments will increase chemical costs, fuel, labor, and machinery expenses (Derksen and Breth, 1994), so the best method to estimate distribution is with a vertical patternator (Pergher G., 2004).

If all the pesticides do not come onto the desired target, a large part is lost. In apple orchards, pesticide losses to the ground ranged from 14 to 39% of the total dose applied (Buisman, Sundaram, Sundaram and Trammel, 1989; Raisigl, Felber, Siegfried and Krebs, 1991), and drift losses ranging from 23% to 45% (Planas and Pons 1991, Siegfried and Raisigl, 1991) have been reported. Good coverage doesn't mean good biological efficiency. For the evaluation of biological efficiency, it might be crucial to determine the distribution of the spray liquid within the canopy. For this purpose analytical methods, which determine the amount of captured tracer in a quantitative way are expected to be the most reliable. Nevertheless, coefficients of variation (CV) between ranges 40-80, the variability within individual trees and between individual leaves is even twice as large (Praat, Mankletow, Suckling and Maber, 1996). Another problem is that some leaves have a better position in relation to the nozzle, while other leaves do not. So, leaves with a better position will have better coverage. Deposits from directly exposed leaves are much higher than those from both partially or badly exposed leaves (Perger and Gubiani, 1995; Perger Gubiano and Tonetto, 1997). Also, one of the larger problems is the loss of the pesticides with higher airflows. The spray displacement is strongly infuenced by the air jet velocity and volume. In-canopy deposits delivered at higher air velocities may be greater (Derksen and Gray, 1995) but at the same time the spray emission to the air can also increase (Doruchowski et al., 1996). High air velocities usually increase the spray loss recorded behind the trees and reduce the loss measured on the soil under the trees (Doruchowski et al., 1996.). Many of the commercial mistblowers had a different distribution of air on the left and right sides of the machine, so one task is to reduce this difference (Ade and Venturi, 1995).

MATERIAL AND METHODS

Three different sprayers were tested at "*Belje*", Baranya, Croatia. Sprayer (A) was the "*Tifone Vento"* axial-fan mistblower. The machine's fan outlets were 110 cm in height and 10.5 cm in width (Figure 1). Sprayer (B) was the "*Myers N1500"* axial fan mistblower. The machine's fan outlets were 115 cm in height and 17 cm in width (Figure 2). Sprayer (C) was the "*Hardi Zaturn 1500"* axial fan mistblower. The machine's fan outlets were 156 cm in height and 14 cm width (Figure 3). Each machine had red nozzles with ceramic splint, arranged in a semicircle.

Figure 1. Mistblower (A) Tifone Vento 1500

Slika 1. Raspršivač (A) Tifone Vento 1500

Figure 2. Mistblower (B) Myers N 1500

Slika 2. Raspršivač (B)Myers N 1500

Figure 3. Mistblower (C) Hardi Zaturn 1500

Slika 3. Raspršivač (C) Hardi Zaturn 1500

The apple orchard was set, so its rows were 3.5 m wide. The average tree height was 3.6 m and the tree width was on the average 1.6 m . The WSP papers were stationed at 5 different levels on the tree, the first at 120 cm from the ground and then every 60 cm to the top of the tree (Figure 4). The WSP papers were placed on the face and on the back of the leaves (Figure 5). At every altitude, there were 5 WSP papers and 5 trees were observed. The WSP had the dimensions of 75 mm x 25 mm (18.75 cm^2), and were manufactured by "*Syngenta"*. The treatment was repeated three times for each machine.

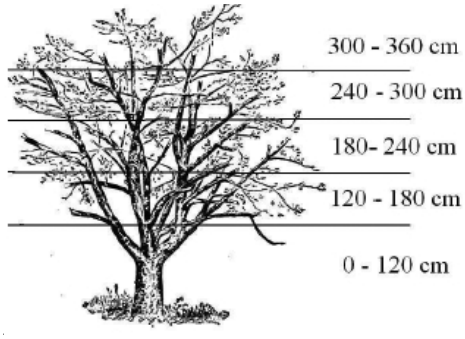

Figure 4. Measuring altitude
Slika 4. Visine mjerenja

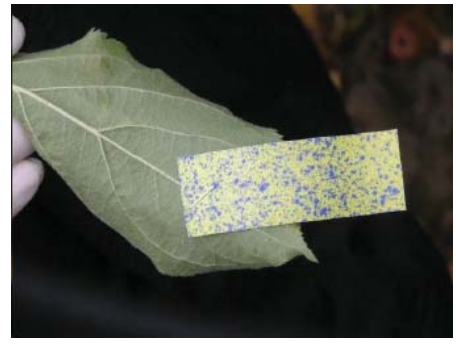

Figure 5. WSP papers on the apple trees
Slika 5. Vodoosjetljivi papirići ma stablima jabuke

After field testing, the samples (WSP) were collected, i.e. every sample from every altitude, from every treatment. The samples were then photographed in special photo chambers, and analyzed with special softwares, so that we could get average WSP coverage, i.e. leave coverage.

Image analysis

After field testing, the WSP samples were collected. Each WSP sample collected from the field was analyzed by using the Image analysis method. The basic elements of the Image analysis system used in this research were a lightening chamber with 6 halogen lamps (which provided illumination of 1360±5 Lux to the sample area), a background from which pictures of the sample were taken with a digital camera (Canon EOS 1000D), and software for image pre-processing and analysis (IrfanView, Adobe Photoshop®, Global Lab Image/2 and Graduate). The WSP samples for imaging were placed 60 cm from the camera.

The images were captured with a digital camera in JPG format. All the captured images were prepared for furthered analysis; using IrfanView 4.0 and Adobe Photoshop® software they were converted to bitmap (BMP) graphic format with an 8-bit pallet ($2^8=256$ colours). This graphic format stores information about colours in RGB-triplets for every pixel on the image, where red (R), green (G) and blue (B) are in intensities of mentioned colours in ranging from 0 to 255. The software Graduate, which was made for this research, calculated the average percentage of red (R), green (G) and blue (B) colour in every pixel on the WSP sample surface while the background was not used in analysis. The results were separated into R, G and B channels, and the percentage shares for blue colour were calculated. An average share of blue colour ($AVG_{(B)}$) on the WSP sample surface was presented as a final result and calculated as:

$$AVG_{(B)} = \frac{B}{\sum RGB} * 100 \quad (\%)$$

RESULTS AND DISCUSSION

Weather conditions

The weather was good for the field experiment with air temperatures of 16.4 °C to 17.7 °C, and air humidity of 51.9 % to 61.2 %. The wind speed ranged from 0.8 to 1.6 m/s from the West and solar radiation decreased from 293 W/mm^2 (at the start of testing, 11.30 h) to 189 W/mm^2 (at the end, 14.45 h). The weather conditions were measured by the"*Hobbo*" weather station.

Wind velocity at different heights of the mist blower outlet

Depending of mist blower fan outlet, we measured 6 levels (Figure 6) of wind velocity from three different mistblowers. Wind velocity was measured just 15 – 20 cm beside the fan outlet by "*Silva Windwatch*".

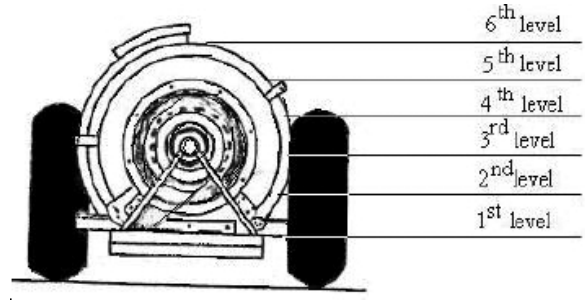

Figure 6. Levels of measuring wind velocity at mistblower
Slika 6. Visine mjerenja brzine zraka na raspršivaču

The "Tifone Vento" (A) outlet was 110 cm in height so we divided it at every 18 cm, except for the last one, which was 20 cm. The first level was from 0 – 18 cm, the second was from 18 – 36 cm, etc. The results, from the left and right sides, which we obtained from the testing, are shown in Figure 7.

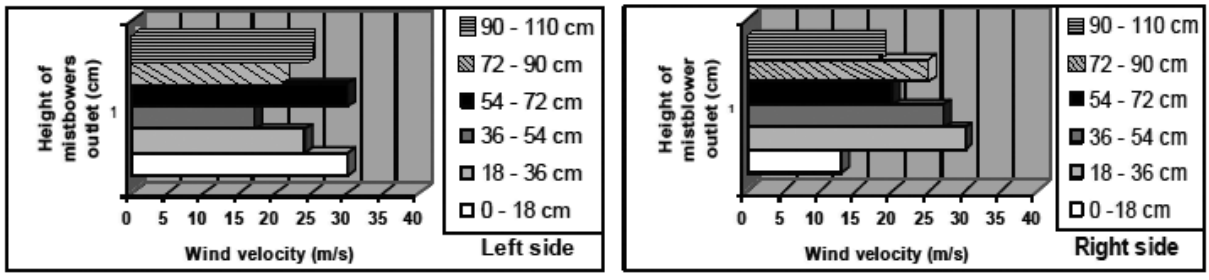

Figure 7. Distribution of wind velocity at different levels of the Tifone mistblower

Slika 7. Raspodjela brzine zraka na različitim visinama kod "Tifone" raspršivača

The max wind velocity on the left side was 30 m/s at the first (0 – 18 cm) and the fourth level (54 – 72 cm), and the minimum was 17 m/s at the third level (36 – 54 cm). On the right side the maximum wind velocity was also 30 m/s at the second level (18 – 36 cm), and the minimum was 18 m/s at the first level (0 – 18 cm). The average wind velocity on the left side was 24.16 m/s, and on the right side 20.66 m/s. The average amount of air on the left side was 10048 m3/h, and on right side 8590 m^3/h, so the total amount of air was 18638 m^3/h.

The "Myers N1500" (B) outlet was 115 cm in height so we divided it at every 19 cm, except for the last one, which was 20 cm. So, the first level was from 0 – 19 cm, the second was from 19 – 38 cm, etc. The results from the left and right side, which we obtained from the testing, are shown in Figure 8.

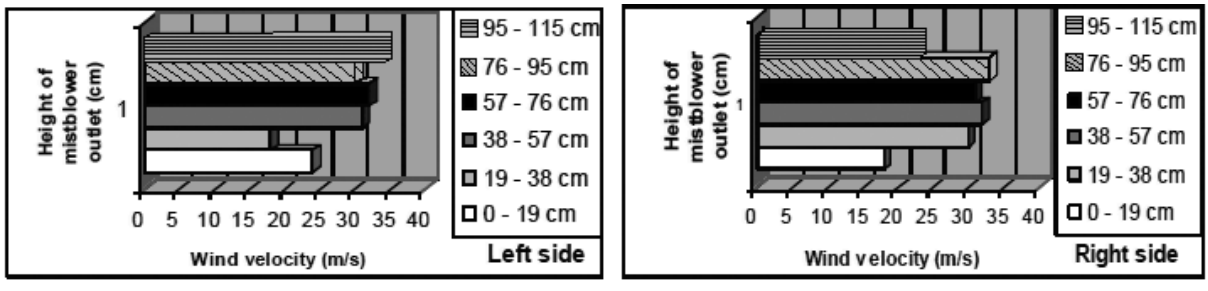

Figure 8. Distribution of wind velocity at different levels of the Myers mistblower

Slika 8. Raspodjela brzine zraka na različitim visinama kod"Myers" raspršivača

The max wind velocity on the left side was 34 m/s at the sixth level (95 - 115 cm) and the minimum was 18 m/s at the second level (19 - 38 cm). On the right side, the max wind velocity was 33 m/s at the fifth level (76 - 95 cm), and the minimum was 18 m/s at the first level (0 – 19 cm). The average wind velocities on the left side was 25.5 m/s, and on the right side 27.0 m/s. Average amount of air on the left side was 18120 m^3/h, and on the right side 18460 m^3/h, so the total amount of air was 36580 m^3/h.

The "Hardi Zaturn "(C) outlet was 156 cm in height so we divided it at every 26 cm. So the first level was from 0 – 26 cm, the second from 26 – 52 cm, etc. The results from the left and right side, which we obtained from the testing, are shown in Figure 9.

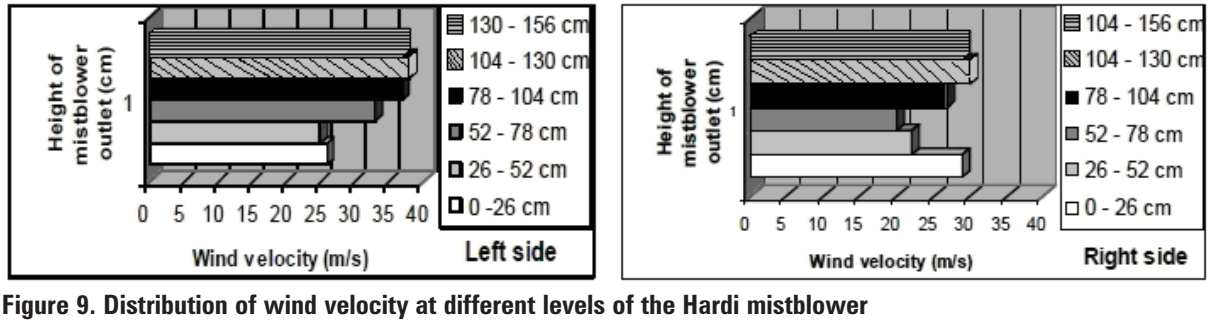

Figure 9. Distribution of wind velocity at different levels of the Hardi mistblower

Sika 9. Raspodjela brzine zraka na različitim visinama kod "Hardi" raspršivača

The max wind velocity on the left side was 38 m/s at the fifth level (104 - 130 cm), and the minimum 25 m/s at the second level (52 - 78 cm). On the right side, the maximum wind velocity was 30 m/s at the fifth level (104 - 130 cm), and the minimum was 20 m/s at the third level (52 - 78 cm). The average wind velocity on the left side was 33.0 m/s, and on the right side 26.0 m/s. Average amount of air on the left side was 24940 m^3/h, and on right side 19650 m^3/h, so the total amount of air was 44590 m^3/h.

Water sensitive paper (WSP) coverage

For this method, the air humidity must be below 80 % because the WSP turns blue at this moisture level (Hołownicki et al.). The *"Tifone"* (A) mistblower had an average WSP coverage of 44.05 %, on left side and 41.33 % on the right side (Figure 10). The greatest WSP coverage on the left size was 75.76 % at the first level (0 – 120 cm), and the minimum was 24.31 % at the third level (180 – 240 cm). On the right side the greatest WSP coverage was 67.94 % at the second level (120 – 180 cm), and the minimum was 10.17 % at the first level (0 – 120 cm).

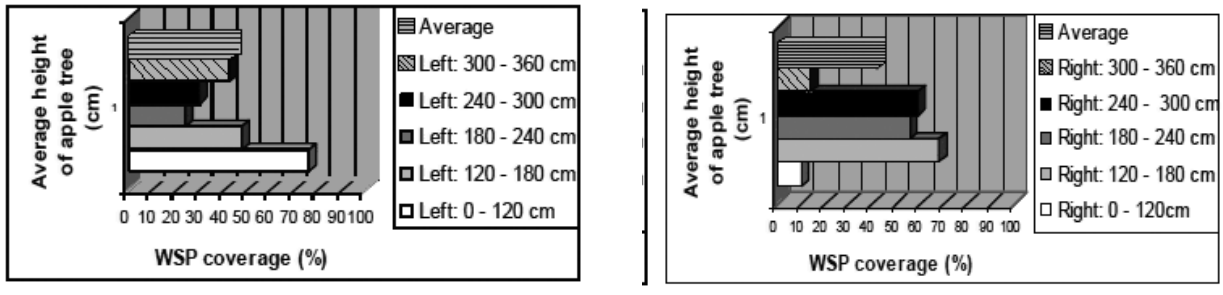

Figure 10. WSP coverage with the Tifone Vento mistblower

Slika 10. Pokrivenost vodoosjetljivih papirića kod "Tifone Vento" raspršivača

The „Myers" (B) mistblower had an average WSP coverage of 33.61 %, on the left side and 37.98 % on the right side (Figure 11.). The greatest WSP coverage on the left size was 67.95 % at the second level (120 – 180 cm), and the minimum was 0.93 % at the fifth level (300 - 360 cm). On the right side the greatest WSP coverage was 90.25 % at the first level (0 – 120 cm), and the minimum was 3.79 % at the fifth level (300 – 360 cm).

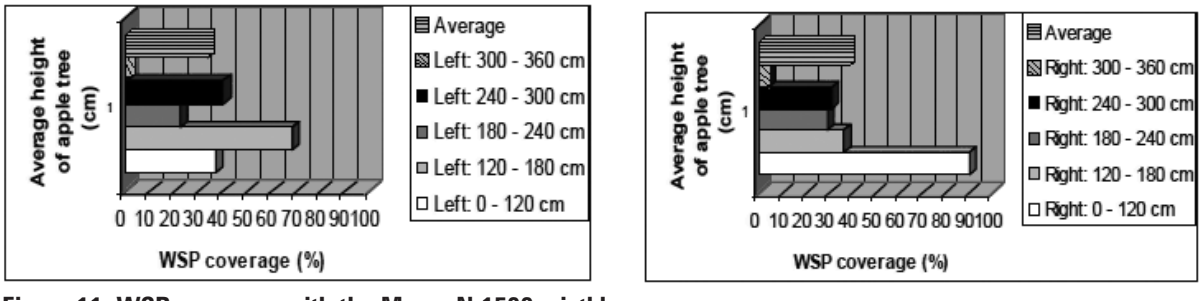

Figure 11. WSP coverage with the Myers N 1500 mistblower

Slika 11. Pokrivenost vodoosjetljivih papirića kod " Myers N1500" raspršivača

The „Hardi" (C) mistblower had an average WSP coverage of 45.85 % on left side, and 42.47 % on the right side (Figure 12.) The greatest WSP coverage on the left side was 94.48 % at the first level (0 - 120 cm), and the minimum was 14.08 % at the fourth level (240 - 300 cm). On the right side the greatest WSP coverage was 58.81 % at the second level (120 - 180 cm), and the minimum was 20.32 % at the third level (180 - 240 cm).

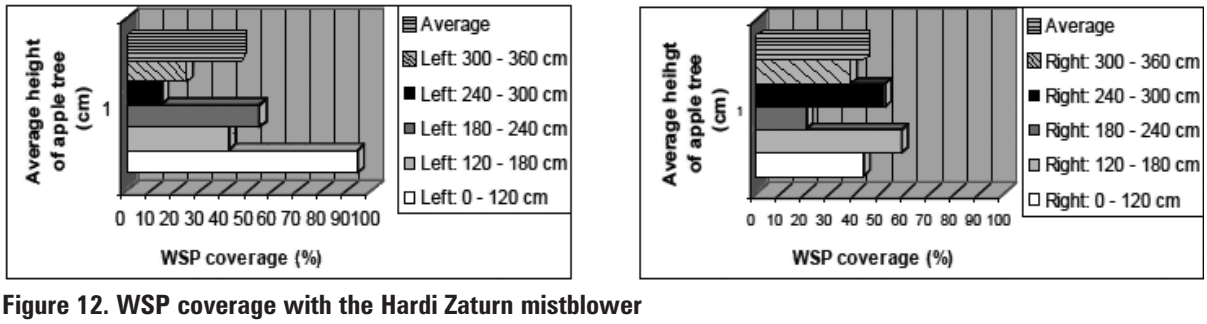

Figure 12. WSP coverage with the Hardi Zaturn mistblower

Slika 12. Pokrivenost vodoosjetljivih papirića kod " Hardi Zaturn" raspršivača

The *Tifone*" mistblower had the greatest coefficient of variation of wind velocities (26 % on the left, and 28.4 % on the right), and *Hardi"* mistblower had the lowest one. (17. 8 % on the left side, and 15. 9 % on the right), Table 1.

Table 1. Wind velocities at six different levels with three different mistblowers

Tablica 1. Brzina zraka na šest različitih visina kod tri različita raspršivača

Heights (1– 6) = the factor B	Wind velocity at different heights of the mistblowers outlet (factor A)							
	Type of mistblower							
	Tifone Vento 1500		Myers N 1500		Hardi Zaturn		Mean B	
Height of treatments	Left	Right	Left	Right	Left	Right	Left	Right
1. level	30	13	24	18	26	29	26.6	20.0
2. level	24	30	18	30	25	22	22.3	27.3
3. level	17	27	31	32	33	20	27.0	26.3
4. level	30	20	32	31	37	27	33.0	26.0
5. level	20	25	30	33	38	30	29.3	29.3
6. level	24	18	34	23	37	29	31.6	23.3
Mean A	24.1	22.1	28.1	27.8	32.6	26.1	28.3	25.3
Stdev	5.2	6.3	6.0	5.9	5.8	4.1		
CV	21.6	28.4	21.3	21.4	17.8	15.9		

The *"Hardi"* mistblower had the best WSP coverage with an average coverage of 45.8 % on the left side (68.3 % CV) and 42.4 % on the right side (34.7% CV), but "*Tifone"* mistblower had the smallest variation between the two sides (45. 4 % on the left and 65.8 % on the right). The "*Myers"* mistblower had the smallest WSP coverage among these three mistblowers (39.9 % on the left and 30.8 % on the right), Table 2.

Table 2. WSP coverage at five different levels with three different mistblowers

Table 2. Pokrivenost vodoosjetljivih papirića na pet različitih visina kod tri različita raspršivača

Heights (1– 5) = the factor B	Water sensitive paper (WSP) coverage with different mistblowers (factor A)							
	Type of mistblower							
	Tifone Vento 1500		Myers N 1500		Hardi Zaturn		Mean B	
Height of treatments	Left	Right	Left	Right	Left	Right	Left	Right
1. level	75.7	10.1	36.9	90.2	94.4	43.2	68.8	47.8
2. level	47.5	67.9	67.9	36.0	41.9	58.8	52.4	54.2
3. level	24.3	55.4	22.3	28.9	54.3	20.3	36.6	34.8
4. level	30.1	59.3	39.9	30.8	14.0	52.0	28.0	47.3
5. level	42.4	13.7	0.9	3.7	24.3	38.0	22.5	18.4
Mean A	44.0	41.2	33.6	37.9	45.8	42.4	41.1	40.5
Stdev	20.0	27.2	24.6	31.7	31.3	14.7		
CV	45.4	65.9	73.2	83.6	68.3	34.7		

Bad spray coverage is a major contributing factor in poor disease control in Croatian circumstances. Therefore, the orchard from this research is treated minimum four times every year against Monilia fructigena. Due to bad spray coverage, this disease always survives on one section of the tree not properly sprayed. So after some time, the disease is back. If the protection was good from the beginning, a third or fourth spraying would most likely not need. To solve the problem of poor spray coverage, large amounts of fungicide must be applied for adequate control. This result is the unnecessary toxication of all agroecological systems, people, and animals and in the end, the apples themselves, as food.

In this research we found out that the "*Hardi"* mist blower was best, but the average coverage on its right side was only 42.7 % , which was enough. This is the reason why these diseases are constantly returning. The situation with the other tested mistblowers was even worse. We also found out that mist blower with the largest amount of air had the greatest coverage (*Hardi*).

CONCLUSION

- The evaluation of spray coverage on WSP is the best method of evaluation to describe relative application quality in an orchard, but the results must be verified in a phytopathological laboratory
- None of the tested mistblowers have a sufficient level of coverage so they must go for technical service to correct their parameters of application.
- Hardi had the best coverage of the tested mistblowers with the highest air volume of the fan.

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UPOTREBA VODOOSJETLJIVIH PAPIRIĆA ZA PROCJENU POKRIVENOSTI LISNE POVRŠINE U VOĆNJAKU JABUKE

SAŽETAK

U radu su prikazani rezultati istraživanja tri raspršivača pri radu u voćnjaku jabuke tijekom listopada 2008. Prilikom usporedbe korištena je čista voda uz primjenu metode vodoosjetljivih papirića (VOP). Širina redova u nasadu iznosila je 3,5 m, uz prosječnu širinu krošnje od 1,6 m, i visinu stabla od 3,6 m. Ispitivani raspršivači bili su opremljeni mlaznicama „Albuz ATR 80"(crvene boje), a sva ispitivanja obavljena su pri 540 min^{-1} priključnoga vratila traktora. Prosječna temperatura zraka u vremenskom intervalu ispitivanja iznosila je 17,05 °C, s prosječnom vrijednosti vlažnosti zraka 56,50%. Prosječna brzina vjetra iznosila je 0,90 m/s u smjeru rada raspršivača. Testirani raspršivači bili su „Tifone Vento", „Myers N1500" i „Hardi Zaturn". „Tifone Vento" imao je sljedeće parametre rada: hektarsku dozu vode od 1000 l, maksimalnu brzinu zraka od 30 m/s i ukupnu količinu zraka od 18 638 m^3/h, 14 mlaznica, radnu brzinu od 5 km/h i radni tlak od 17 bar. „Myers N1500" imao je sljedeće parametre rada: hektarsku dozu vode od 1000 l, maksimalnu brzinu zraka od 34 m/s i ukupnu količinu zraka od 36580 m^3/h, 14 mlaznica, brzinu kretanja od 5 km/h i radni tlak od 11 bara, dok je „Hardi Zaturn" imao hektarsku dozu vode od 1000 l, maksimalnu brzinu zraka od 38 m/s i ukupnu količinu zraka od 44590 m^3/h, 18 mlaznica, brzinu kretanja od 5 km/h i radni tlak od 7 bara. Raspršivač „Tifone" na lijevoj strani stroja imao je prosječnu količinu zraka od 10048 m^3/h te je ostvario prosječnu pokrivenost na VOP-u od 44,05 %. Na desnoj strani stroja utvrđena je prosječna količina zraka od 8590 m^3/h i prosječna pokrivenost na VOP-u od 41.33 %.

Raspršivač „Myers" na lijevoj strani stroja imao je prosječnu količinu zraka od 18120 m^3/h te je ostvario prosječnu pokrivenost na VOP-u od 33.61%. Na desnoj strani stroja utvrđena je prosječna količina zraka od 18460 m^3/h i prosječna pokrivenost na VOP-u od 37.98%

Kod raspršivača „Hardi" utvrđena je prosječna količina zraka na lijevoj strani od 24940 m^3/h te je postigao prosječnu pokrivenost na VOP-u od 45.85 %. Na desnoj strani stroja utvrđena je prosječna količina zraka od 19650 m^3/h i ostvarena je prosječna pokrivenost od 42,47 % na postavljenim VOP-ima. Prilikom istraživanja korištena je metodika, pri čemu su VOP fotografirani, a slike su konvertirane softverom "Irfan View 4.0" te kasnije obrađivane "Adobe Photoshopom", "Global Lab Image/2" i "Graduate" softverom.

Ključne riječi: raspršivač, vodoosjetljivi papirići, zračna struja, voćnjak jabuke, brzina zraka

(*Received* on 18 March 2010; accepted on 12 May 2010 - *Primljeno 18. ožujka 2010.; prihvaćeno 12. svibnja 2010.*)