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INCREASING THE EFFICIENCY OF SPRAYING OF ORCHARDS

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Abstract: Orchards are sprayed at the agro-technical speed ranging from 4 to 6 km per hour. The research paid attention to the influence of a higher speed reaching 8 km/h on the quality of orchard trees spraying. Applying higher speed causes a labour efficiency increase while spraying and reduces time of treatment performance. However, increasing the speed should not decrease the quality of leaf coverage with the sprayed liquid. The results of the carried out research indicate a possibility of increasing the working speed without deteriorating the quality of spraying in dwarf orchards.

Key words: working speed, spraying quality, coverage of orchard, air – assisted sprayer

INTRODUCTION

The efficiency of spraying in an orchard depends on the width of row spacing and working speed of the sprayer. The row spacing width in dwarf orchards may reach 3.5 m and it should not be increased since its broadening will cause reduction of the number of trees and also the yield. The procedure might though increase the surface efficiency when working speed is kept stable. However, as this solution is not utilized only increasing the working speed can increase the surface efficiency. The applied speed, called agro-technical ranges from 4 to 6 km/h. It is limited in traditional orchards and in dwarf orchards by the application of high spray volumes i.e. 500 l/ha – 1200 l/ha (Bera 1979; 1980; Göhlich 1985; Szewczyk 1996).

The development of construction of spraying appliances in orchard sprayers brought about a tendency to limit the spray volumes down to 200 l or even lower. Application of recycling sprayers allows reducing volumes of liquid and plant protection products, but does not allow increasing a working speed. This type of sprayers does not create a possibility of increasing its surface efficiency especially due to its complicated drive with a complex construction of the spraying system.

Presently used orchard sprayers can move into the area of orchards at a higher speed. Increasing spraying speed, in conditions of keeping stable parameters of the liquid pressure and spray liquid flow rates, will cause a certain decrease of spray volume. Spray volume lower than in Poland and ranging from 100 – 200 l/ha are applied in the US and Western Europe (Cross 1991; Koch and Weisster 1994; Cross et al. 2000). More and more frequently various nozzles produced by foreign companies such as : Spraying Systems Corporation, Desmarques, Lechrer, Hardi, Spraying International and many others are used in Poland. The same models of nozzles are used in E.U. In the orchards there are cultivated the same cultivars of fruit trees and also the same pesticides are applied. It seems then that in the situation described , there is no obstacle to apply the suggested lower spray volumes.

The aim of the work was to test if the increase of working speed will not influence negatively the quality of tree leaves spraying.

METHODS AND MATERIALS

Two – axial fan orchard sprayers : Pilmet 1014 Sad and Agrola 1000 eco were used for spraying dwarf apple orchard (Gloster variety).

The Pilmet sprayer was equipped with the swirl nozzles AMT 015 and axial fan air-blast with maximum air volume 31,000 m^3/h. The AGROLA sprayer was equipped with the flat spray tip TeeJet 80015 and axial fan air-blast with air volume 20,000 m^3/h. The working parameters of the Pilmet and Agrola sprayers are shown in table 1. The liquid was pure water at the temperature of 15°C.

Two working speeds were used while spraying the orchard with the Pilmet sprayer i.e. 5.0 and 8.3 km/h and three liquid volumes per hectare: 260, 322 and 535 l/ha. The speeds of 5.1 and 8.2 km/h and spray volumes 267, 325 and 541 l/hectare were applied while spraying with Agrola.

The temperature of the air during the tests was about 17–19°C, the relative air humidity about 55–60% and the wind speed oscillated about 1–2 m/s.

Water sensitive papers (size: 26 × 38 mm) were used as spray collectors to measure spray coverage s_k. The collectors were placed on leaves at random at three levels: I – on a tree at the height of 2 m ; II – on a tree at the height of 1 m and III – on the ground under trees. At each level six leaves were selected at random to clip the papers. The measures were repeated five times, in one row on each fifth tree. The mean height of the trees amounted to 2.7 m , row spacing 3.5 m and tree spacing 2.6 m. The trees were at the first fruit bearing stage.

Table 1. Working parameters of sprayers Pilmet i Agrola

Type of sprayer	Working speed (km/h)	Liquid pressure (MPa)	Flow rate (l/min)	Air volume (m^3/h)	Spray volume (l/ha)
Pilmet 1014 Sad	8.3	1.0	12.6	20 000	260
	8.3	1.5	15.6	20 000	322
	5.0	1.5	15.6	20 000	535
Agrola 1000 eco	8.2	0.8	12.8	20 000	267
	8.2	1.0	15.6	20 000	325
	5.1	1.1	16.1	20 000	541

The coverage was described using the analysis of an image. The image was takenwith the set consisting of the Panasonic color CCTV camera and a computer. The resolution of the camera was 330 TV lines. The measured surfaces of papers were 2 cm^2. The special Multiscan program for the analysis of the image was installed in the computer. Error did not exceed 2%.

The variance analysis applying Student's multiple range test t at the significance level of $\alpha=0.05$ was used for the purpose of statistical analysis. The data from the tests (spray coverage s_k) in the general population were presented in the form of Box & Whisker Plot.

RESULTS

Distribution of spray coverage s_k on trees while spraying with Pilmet sprayer and spray volumes of 260, 322 and 535 l/ha at three levels is presented in figure1. The chart presents marked means (medians) placed within 25–75 % of the population of the obtained results and also the spread of all the results (min – max). With a fairly significant spread of the values at both levels on trees (level I and II), at level I the values of medians are close to one another while applying all the volumes. At level II only the median for spray volume 535 l/ha is significantly different and reaches higher values. However, the spray coverage of the samples spread on soil (level III) is very small and the values of s_k index are very close to one another.

The distribution of the spray coverage s_k on the apple tree leaves while applying Agrola sprayer with spray volumes of 267, 325 and 541 l/ha at three levels, is pre-

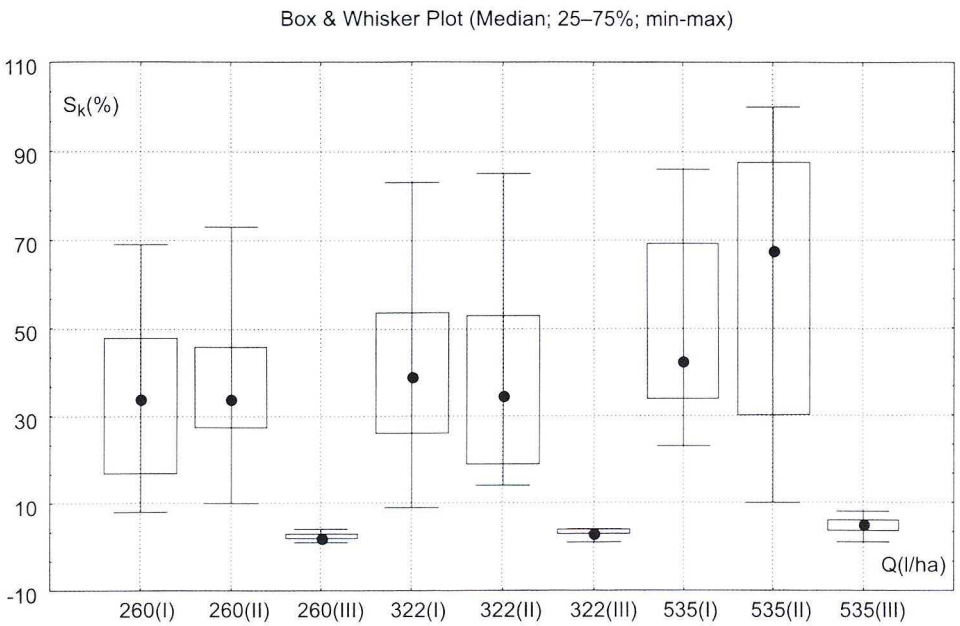

Fig. 1. Distribution of spray coverage s_k on apple tree leaves (at levels I, II, III – applying Pilmet sprayers)

sented in figure 2. The distribution of means and of spread of the results at two levels on the trees is similar to the results obtained while performing the treatment with the Pilmet sprayer. However, the coverage of samples on the ground shows a more considerable spread of the results and a higher diversification of median values.

Means of spray coverage s_k obtained while applying the Pilmet sprayer are gathered in table 2. The highest spray coverage at two levels and on the soil is achieved using the spray volume of 535 l/ha. Means in the columns marked with the same letter do not differ statistically. It is evident from the statistical analysis that tree spray coverage means at both investigated levels (260 l/ha and 322 l/ha spray volumes) do not differ significantly. Whereas, the spray coverage of samples set up un-

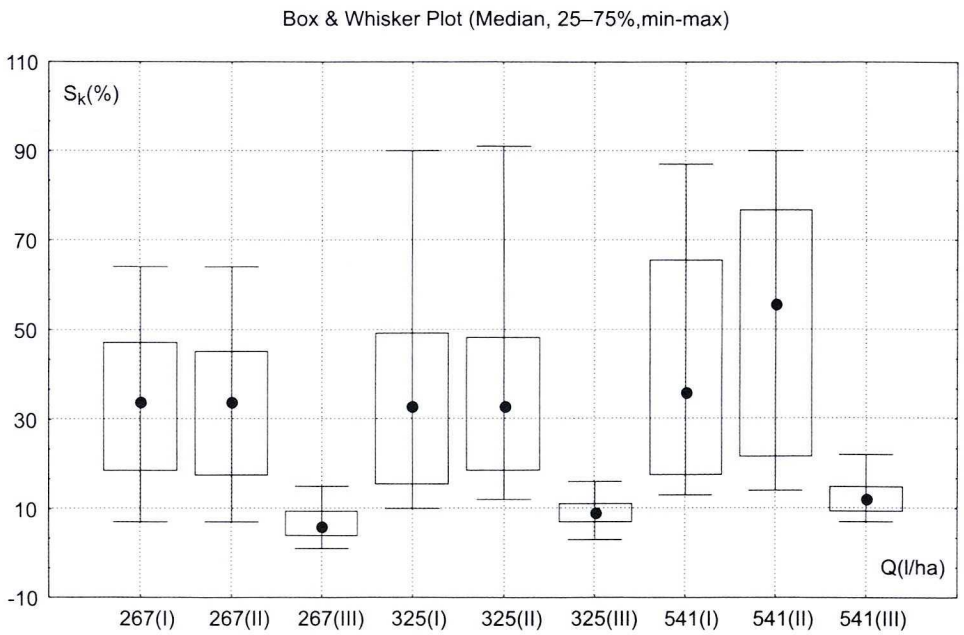

Fig. 2. Distribution of spray coverage s_k on apple tree leaves (at levels I, II, III – applying Agrola sprayers)

Table 2. The spray coverage s_k while applying Pilmet sprayer for apple trees spraying

Spray volume (l/ha)	Spray coverage s_k (%)								
	Level I			Level II			Level III		
	Mean	Std. Dev.	Std. Error	Mean	Std. Dev.	Std. Error	Mean	Std. Dev.	Std. Error
260	32.9a*	17.6	3.2	36.9a	17.0	3.1	2.3	0.7	0.1
322	38.8a	18.9	3.5	39.1a	19.8	3.6	3.2	0.8	0.1
535	49.2	20.3	3.7	59.5	31.4	5.7	4.8	1.7	0.3

*Means in the columns marked with the same letter do not differ statistically

der the trees do differ significantly. The results have shown that the increase of the spray volume causes larger liquid losses.

The spray coverage means s_k obtained while spraying with Agrola are presented in table 3. The volumes applied are very similar to the ones used while spraying with Pilmet. The results are different, though. At level I the mean leaf coverage is not significantly different despite a significant diversification of volumes. At level II, the mean leaf coverage for spray volumes 541 l/ha and 325 l/ha does not differ importantly, either. The values of spray coverage of samples spread on the ground are higher than while spraying with Pilmet. The s_k value of 12.7% indicates a vital liquid loss while spraying with 541 l/ha volume.

Table 3. The spray coverage s_k while applying Agrola sprayer for apple trees spraying

Spray volume (l/ha)	Spray coverage s_k (%)								
	Level I			Level II			Level III		
	Mean	Std. Dev.	Std. Error	Mean	Std. Dev.	Std. Error	Mean	Std. Dev.	Std. Error
267	33.3a	16.6	3.0	32.6a	16.3	3.0	6.9a	4.0	0.7
325	36.6a	22.4	4.1	38.2ab	22.7	4.1	8.8a	3.4	0.6
541	43.5a	25.9	4.7	50.9b	28.6	5.2	12.7	4.3	0.8

*Means in the columns marked with the same letter do not differ statistically

Analysing the effects of the spray coverage a special attention should be paid to the applied working speeds. The velocities are the decisive elements as far as surface efficiency is concerned. The effective efficiency (W_1) is 1.75 ha/h while applying the speed of 5 km/h during spraying the investigated orchard. Whereas, while spraying at 8 km/h it equals 2.8 ha/h, so it is 60% higher. Using both a higher working speed and lower spray volume serves a double profit.

Means of leaf coverage on the surface of the whole tree and on the ground under the tree are presented in figure 3. Confidence intervals are marked at mean spray coverage. The spray coverage differ considerably when working speeds in Pilmet sprayer reach 5 km/h and 8.3 km/h. When 5.1 km/h and 8.2 km/h speeds in Agrola were applied the spray coverage did not differ significantly. When lower spray volumes were used i.e. 260 l/ha and 267 l/ha, the spray coverage still reached high values in every case, on the average 34.9% and 33% accordingly, for the spray volumes on the tree. The 15% coverage is regarded as sufficient in the case of cereals spraying.

CONCLUSIONS

Increase of working speed to 8 km/h is suitable. A significant increase of effective surface efficiency by 60% on the average is achieved.

Increasing the working speed without changing the set of nozzles (this change usually involves some financial costs for many farmers), leads to obtaining an additional profit connected with a reduction of the applied spray volume from 500–750 l/ha to 260 l/ha.

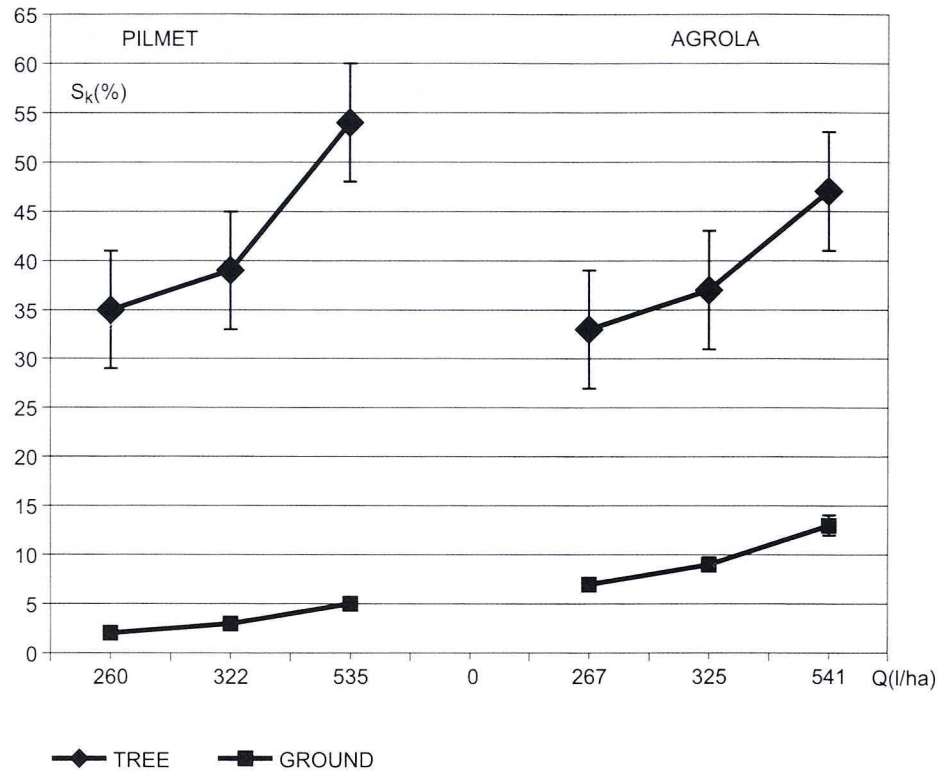

Fig. 3. Dependence of spray coverage s_k on spray volume Q while applying Pilmet and Agrola sprayers on apple trees

The reduction of the volume creates no serious risk since spraying with traditional sprayers the spraying quality described as spray coverage is relatively high and reaches over 30%.

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POLISH SUMMARY

ZWIĘKSZENIE WYDAJNOŚCI OPRYSKIWANIA SADÓW

Sady opryskuje się z prędkością agrotechniczną zawierającą się w granicach 4–6 km/h. Celem pracy było sprawdzenie czy zwiększenie prędkości roboczej opryskiwacza do 8 km/h, nie spowoduje pogorszenia się jakości opryskiwania liści drzew.

Większość obecnie stosowanych opryskiwaczy ma urządzenia opryskujące w postaci przystawek wentylatorowych, tradycyjnych z wentylatorami osiowymi lub promieniowymi lub przystawek nowocześniejszych kolumnowych nabudowanych na wentylatory osiowe lub poprzeczne. Tego typu opryskiwacze mogą poruszać się po sadzie z większą prędkością.

Zwiększenie prędkości opryskiwania przy zachowaniu stałych parametrów ciśnienia cieczy i wydatku jednostkowego urządzenia opryskującego spowoduje zmniejszenie dawki cieczy na hektar. W związku z tym należy również sprawdzić jaki jest wpływ niższych dawek cieczy na hektar na jakość opryskiwania drzew.

Do opryskiwania sadu jabłoniowego karłowego (odmiana Gloster) zastosowano dwa opryskiwacze sadownicze: Pilmet 1014 Sad and Agrola 1000 eco. Podczas wykonywania zabiegu opryskiwaczem Pilmet stosowano dwie prędkości robocze: 5,0 i 8,3 km/h i trzy dawki cieczy na hektar wynoszące: 260, 322 i 535 l/ha. Przy opryskiwaniu opryskiwaczem Agrola stosowano prędkości 5,1 i 8,2 km/h oraz następujące dawki cieczy: 267,325 i 541 l/ha.

Na rycinie 3 przedstawiono średnie wartości pokrycia liści na całym drzewie i na gruncie pod drzewem dla obu stosowanych opryskiwaczy. Przy średnich wartościach pokrycia zaznaczono przedziały ufności. W przypadku opryskiwania opryskiwaczem Pilmet wartości pokrycia przy stosowanych prędkościach roboczych 5,0 km/h i 8,3 km/h różnią się istotnie, a przy opryskiwaniu opryskiwaczem Agrola przy prędkościach 5,1 km/h i 8,2 km/h nie różnią się istotnie. W każdym przypadku przy zmniejszonych dawkach cieczy tj. 260 l/ha i 267 l/ha wartości stopnia pokrycia w dalszym ciągu osiągają znaczne wartości, średnio na drzewie dla tych dawek cieczy odpowiednio 34,9% i 33%. Przy opryskiwaniu zbóż przyjmuje się, za wystarczające pokrycie powyżej 15%.

Zwiększenie prędkości roboczej do 8 km/h jest celowe, ponieważ osiąga się znaczne zwiększenie efektywnej wydajności powierzchniowej – średnio o 60%.