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INFLUENCE OF THE MODERN SPRAYER CALIBRATION ON THE QUALITY OF APPLICATION

SUMMARY

In this research are showed results of the exploatational research of the new, modern, tow-type sprayer under field conditions in the treatment of young apple orchards. The assignment test was to determine the actual loss of the liquid due to the inadequate adjustment and to provide guidelines how to reduce the loss of the liquid in the same treatment conditions. The tests aim to detremine the optimal work mode that allows you to reduce both spray drift, in air and on soil, and with that to minimize the loss of protective material outside the treatment zone. The aim of the research is to increase efficiency through increased distribution efficiency and precision of the device. Before the calibration process was noted the norm of the treatment of 520 *l/ha* while the average coverage of the crown was 35,29%. With that norm were noted losses of the working fluid from 17,21% in the form of spray drift in air and 34,98% in the form of spray drift on soil. After calibration, gauging and adjustment of the sprayer it was achieved an average coverage of the crown of 38,05% with norm of the treatment of 290 *l/ha*. In less norm loss in the form of spray drift on soil come to only 8,56% and 14,71% of spray drift in air, which means that the coverage of the plate, which measures the losses, is considerably reduced.

Test results indicate losses that occur due to the spray drift in air and on soil, which are highly expressed in young seedlings in which the crown is underdeveloped. It is important to emphasize that in this tests in a young plantation standard treatment from 520 *l/ha* was reduced to 290 *l/ha* while retaining the quality and even with a slight improvement in terms of coverage of the crown and efficiency of protection. Test results show that despite the use of modern and expensive sprayer, due to incorrectly settings, comes to significant losses in the form of spray drift. The above mentioned problems can be minimized by proper adjustment of the device calibration.

Keywords: calibration, applications, spray drift losses

INTRODUCTION

The chemical method is today the most effective in combating diseases, pests and weeds, and plays an important role in achieving large crops of high

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quality. In recent times growing importance is given to the research of the alternative methods of plan protection. It is quite evident that this method of protection will be used also in the future what leads to the fact that pesticides should be used rational and all in order to decrease the quantity of chemical substances to be applied and the number of treatment. Researches in previous years have shown the opposite, frequent infections require a large number of treatments during the year, sometimes up to 20 times (Maličević, 2010).

That about all of this makes sense to talk confirms the fact that materials for plant protection of new generation are far more selective, less toxic to humans and animals and much more biologically active (e.g. requires only a few grams of material per hectare). The application of such biologically active and selective materials requires improved methods of application and ideal set and perfectly efficient technique for the application of pesticides. This method achieves high precision and effective protection.

Agriculture has at disposal effective technique for pesticide application regarding orientation of the spray jet and the high accuracy of the same distribution on the target surface, and the uniformity of application and care about the environment. Despite that the application of pesticides in Republika Srpska derive mostly from technically and technologically obsolete technology, insufficient measuring and regulating equipment and low exploitation potential. All above mentioned shows that agriculture has on disposal effective technique for applying chemical materials in terms of higher capacity and precision guidance to the target area, while testing in the field shows opposite.

Producers are convinced that the purchase of a high quality and expensive equipment can resolve all problems related to quality of protection, not knowing that inadequate adjustment of the same equipment may be the cause of poor protection. The sprayer Munckhof CP105 is a high precision device from reputable Dutch company, tow type, equipped with tower and it is first year in operation. If the sprayer isn't adapted to the conditions of treatment during operation in field conditions, this may be the cause of big losses of the material and consequently of the poor quality of the application. For material (spray drift) apply outside the target area regularly follows mechanized treatment to a larger or lesser degree, which significantly reduces the quality of protection and directly pollute the environment.

Kaul *et al*. (2002) writes about the distribution of the working fluid by spraying in orchards, indicating that in practical work, during numerous trials and by sprayers with optimally designed device for the treatment, on the land reaches 20% of the material.

Losses can occur due to many factors: weather conditions in which the treatment is carried out (wind speed, temperature and relative humidity), characteristics of the types of sprayers and nozzles, norms and concentration of working fluid and of the competence and skill of the operator on aggregate.

MATERIAL AND METHODS

Testing of the sprayer efficiency in the treatment of young apple orchards was followed by over loss of working fluid in the form of spray drift and carried out directly in the production conditions. Characteristics of plantations obtained from measurements of 10 fruit trees (average height from the ground is 2.50 m, height of the first branch is 1.90 m, crown width is 1.00 m, width of the crown in row spacing is 0.97 m), while row spacing is 3.50 m. Treatment was performed with a sprayer equipped with tower (Figure 2), and this sprayer was first year in operation. Sprayer was equipped with an axial type of blower, and works on the principle of hydrodynamic pneumatic disintegration of liquid jet. During testing on the atomizer were placed nozzles type Albuz ATR 210, ATR 212 and ATR 220, or brown, yellow and red nozzle.

The first step is to determine the condition of the nozzle from the standpoint of capacity, and is determined by measuring beaker and the appropriate adapter (Figure 1). After the diagnostic approaches to calibration that should be carried out according with the development of the fruit crown. The position of the nozzle is determined by its capacity, or in determining the capacity nozzle is placed into the appropriate position. The nozzle capacity before and after calibration is shown in the histogram (Fig. 3. a and b). After diagnostic the protection quality is followed by qualitative method using water sensitive plates directly in production conditions (Figure 2).

Figure 1. Measuring the capacity of the nozzle

Figure 2. Field examination

Method of monitoring the quality of treatment through water sensitive plate is separated into three segments. Measuring plates are following the treatment quality from the standpoint of losses (spray drift in air and on soil) and the quality of protection or coverage of the upper and lower surface of the leaf inside the crown. In the crown of the fruit plates were placed in four altitude zones, measured from land level to the heights of: 60, 120, 180 and 240 cm. The plates that follow the loss of the material in the form of land drift were set every 80 cm, measured from the longitudinal central axis of the unit, which coincides with the middle row area. In total there are 11 positions that follow the loss of spray drift on soil, of which the first plate is located below the unit center, while the other five are on the left and five on the right side, so that the farthest plate is located at 4 m of distance from the central axis of the unit. Spray drift in air is measured using plates that are placed on the pole visor, on the four height positions, i.e. at a distance of each 1 m from the land.

In the treatment with tow-type sprayer it is not possible to change the height of the nozzle cornice from the land, as it is possible at carried sprayer leveling with hydraulics. At tested sprayer, nozzle that was located at the first position is only 38 cm and the other 52 cm from soil which presents a special problem in the treatment of newly planted.

The capacity of air flow during testing is 28.800 m3 / h. Data on the coverage of plates and the number of drops was recorded on the basis of a passage, and was read using a program ImageJ 1.44. The program was developed by the U.S. National Institutes of Health, and is intended for professional analysis and processing of the photography. After collection and labeling, water-sensitive plates are scanned at high resolution, followed by loading and processing (Zhu, *et al*., 2011; Prodanov and Verstreken, 2012).

RESULTS AND DISCUSSION

Ecologically acceptable technology for pesticide application is developed with the intention to reduce consumption of pesticides, along with increase of their efficiency and reducing losses due to spray drift (Sedlar, 2009), and the research in this study confirm this. In the treatment of apple orchards in spite of the application of modern sprayer, there were noted large losses in the form of spray drift. The histogram (Fig. 3) shows the capacity of all nozzles (l/min) before and after calibration.

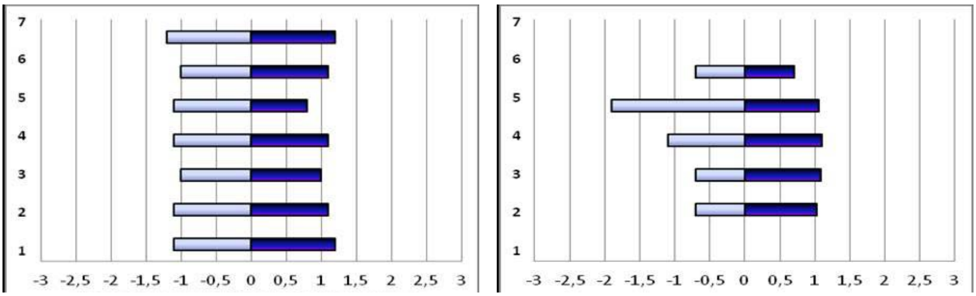


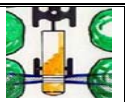
Figure 3. Histogram of the sprayer distribution, before(left) and after calibration(right)

Capacity and location of nozzles have the greatest impact on the correction of losses during application. Therefore it was necessary to determine the position of the nozzles with the appropriate capacity, and histogram (Figure 3 b) shows the position of the nozzles after calibration and adjustment.

Nozzles in position "1" and "7" are switched off because of low and high positions in relation to the development of the crown. Nozzle in position "5" on the left has a capacity of 1.90 l / min, and the most intense flow is required in this position because of the geometry of the crown and the direction of air flow. Since this is a young orchard of underdevelopment crown in position "2", "3" and "6" on the left, and the position of "6" on the right side of the sprayer nozzles ART 210 are adapted. Capacity of the nozzle Albuz type ATR 210 at pressure of 10 bars is 0.68 l / min. This model of nozzle setting aimed to adjust the position according to the capacity and conditions of treatment, i.e. form and shape of the crown.

The results of the quality of application, after shown way of the sprayer calibration, were evaluated on the basis of the losses in the form of spray drift on soil and in air (Table 1 and Table 4). The results show that after calibration was recorded a reduction of spray drift on soil from 35.00% to 8.56% (Table 1).

Table 1. Spray drift on soil, before and after calibration

Plates coverage – on the left side of the sprayer [%]						*Plates coverage – on the right side of the sprayer* [%]				
5	**4**	**3**	**2**	**1**	**0**	**1**	**2**	**3**	**4**	**5**
Spray drift on soil – before calibration										
10,18	18,27	38,63	43,72	49,62	45,34	47,16	49,81	35,17	34,62	11,53
Spray drift on soil – after calibration										
0	3,24	10,06	14,72	13,56	7,31	16,18	10,24	6,45	8,23	4,16

0-The middle of the raw match the central axis of the unit,1-Distance from the middle of the row 0,8 m, 2-Distance from the middle of the row 1,6 m, 3-Distance from the middle of the row 2,4 m, 4-Distance from the middle of the row 3,2 m, 5-Distance from the middle of the row 4,0 m

Therefore, the average coverage of water sensitive plates which measures losses as a spray drift on soil was 35.00% before calibration and after calibration was reduced to only 8.56%. The average coverage of the plates that measure spray drift on soil on the left side from the sprayer was 32.09%, and 35.86% on the right side. After calibration the average coverage of the plates on the left side from the sprayer was reduced to 8.32% and to 9.18% on the right side. It should be emphasized that during testing time was registered intensity of the wind intermittently of 1 to 1.5 m/s from the left side of unit.

The quality of the application from the point of the crown coverage before and after the calibration is shown in Table 2 and Table 3. Table 2 shows the values of upper and lower leaf surface coverage as well as the number of drops inside the crown. The average coverage of the upper and lower leaf surface on the left side of the sprayer is 34.42%, while the average coverage of the right side was slightly higher and it was 37.41%. The coverage of upper leaf surface of the left side was 35.86% and the coverage of the lower leaf surface was slightly lower and it was 32.98%. The upper leaf surface on the right side of the sprayer had an average coverage of 37.94% and the lower leaf surface had 36.88%.

The average number of drops on the left side was 47.88, and on the right side was 47.63. Regarding quality of the treatment and the coverage number of drops was little less on the lower leaf surface. On the left side the average number of drops on the upper leaf surface was 49, and on the lower leaf surface it was 46.75, lower by 4%. Number of drops on the right side of the upper leaf surface was 50.25 and on the lower surface 45, therefore better coverage is for 10% in favor of the right row.

Table 2. Efficiency of the sprayer before calibration

Place of the plate	Left side				Right side			
	Coverage [%]		The number of drops		Coverage [%]		The number of drops	
	Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface
1.	40,84	34,53	54	47	46,34	43,62	57	51
2.	38,72	41,51	50	52	37,13	34,52	48	45
3.	37,23	28,64	51	41	32,86	38,13	46	44
4.	26,64	27,21	41	48	35,41	31,22	50	40
$\overline{x_1}$	35,86	32,98	49,00	46,75	37,94	36,88	50,25	45,00
$\overline{x_2}$	34,42		47,88		37,41		47,63	

The task of the research was to increase the quality of applications through increased distribution efficiency while reducing losses. Table 3. shows the results of the quality of protection, coverage of the upper and lower leaf surface of the crown treated with the same sprayer that has passed measures of calibration.

Table 3. Efficiency of the sprayer after calibration

Place of the plate	*Left side*				*Right side*			
	Coverage [%]		*The number of drops*		*Coverage* [%]		*The number of drops*	
	Upper surface	*Lower surface*	*Upper surface*	*Lower surface*	*Upper surface*	*Lower surface*	*Upper surface*	*Lower surface*
1.	38,64	36,82	49	44	36,46	34,53	48	46
2.	41,51	36,63	54	48	37,52	36,82	51	49
3.	42,83	39,17	56	49	46,17	41,63	61	53
4.	31,62	32,54	47	45	37,62	38,17	49	52
$\overline{x_1}$	38,65	36,29	51,50	46,50	39,45	37,79	52,25	50,00
$\overline{x_2}$	37,47		49,00		38,62		51,13	

$\overline{x_1}$ - *Average of coverage and the number of drops of the upper/lower surface of the leaf*

$\overline{x_2}$ - *Average of coverage and number of drops per side*

The fact that the average coverage of the leaf inside the crown increased from 35.29% to 38.05%, while reducing the norm of 44.00% indicates that calibration of devices make sense. The average coverage of the left side was

37.47%, while the right side is a little higher and was 38.62%. On the upper surface of the leaf on the left side from the sprayer the coverage was realized of 38.65%, while the lower surface of the leaf had less coverage, 36.29%. Regarding the right side of the sprayer the average coverage of the upper leaf surface was 39.45%, and of the lower leaf surface was 37.79%. Number of drops of the left side ranged from 44 to 56 which were fairly uniform for this type of research, and the average was 49 for the left side of the unit. Average number of drops on the right side of the sprayer was 51.13 and ranged from 46 to 61.

On the basis of these results we see that the spray drift is one of the major problems in the process of dew fruit plantations. Especially registered was the spray drift on soil, and he is the result of treatment with incorrectly adjusted sprayers in unsuitable conditions. By larger plantings and by sprayers with a blower with higher capacity it is possible to work if there is a wind speed of 3 m/s, and at smaller plantations can be tolerated wind speed up to 2 m/s (Brčić *et al*. 1995). The intensity of the spray drift in air or the coverage of the water sensitive plates that measure the losses in the form of spray drift in air is shown in Table 4.

Table 4. Spray drift in air, before and after calibration

Place of the plate	Coverage (%)	Number of drops per (cm^2)	Coverage (%)	Number of drops per (cm^2)
	Left side		Right side	
Before calibration				
1 *m*	3,59	17	9,32	29
2 *m*	20,17	36	18,68	37
3 *m*	29,63	53	32,14	51
4 *m*	7,46	28	16,59	35
After calibration				
1 *m*	4,08	16	8,84	21
2 *m*	21,31	39	17,62	32
3 *m*	25,17	45	28,37	43
4 *m*	5,23	26	9,04	33

The average coverage of the plates on the left side from the sprayer before calibration was 15.22%, while from the right side was 19.19%. After calibration the losses in the form of spray drift in air were not significantly reduced as is the case with spray drift on soil. After calibration the coverage of plates that follows spray drift in air on the left side was 13.45%, and on the right side 15.97%. As we can see losses were reduced in the form of spray drift in air from 17.21% to 14.71%. Calibration didn't give expected result when it comes to reducing spray drift in air. The reason for the poor results of the reduction of spray drift in air lies in the fact that it was a young orchard with poorly developed crown and the application in such conditions is extremely difficult. The priority is to achieve good coverage of the crown and in this case a good part of the liquid passes through the space between the seedlings and increases the losses in the form of spray drift in air. Some authors recommend treatment in favorable conditions (Bulgarian, 2008.), while there are propositions to use more large drops compared to the smaller what can be achieved with working pressure, and resulting is reduced spray drift up to 90% (Agrotop Spray Technology, Banaj *et al*. 2010.). The first proposition limits the time of the treatment which is a major problem in big plantation, and the other way of application results small coverage and the possibility of joining of the material from leaf which directly increases the losses. These studies show that high precision and advanced devices for application of pesticides may be the cause of major losses due to inadequate setting. Properly performed calibration of the sprayer resolves all mentioned defects of the pesticide application and provides treatment in bad weather conditions.

CONCLUSIONS

The application of expensive and high precision technique that is not properly adjusted during the application may be cause of large losses of the material, as proved by this study. Obtained results indicate the great benefits of pesticide applications with the sprayer that has passed calibration. Advantages are reflected especially in the saving of pesticides and good quality of water as the carrier, which is difficult to reach during the period of treatment (dry period). After appropriate diagnostic methods and settings that were applied in this study, standard treatment was reduced from 520 *l/ha* in 290 *l/ha*.

The results show that despite the lower rate, the coverage of the leaf has increased by 2.13% (this increase is achieved due to reduced losses in the form of spray drift). The present model is an efficient solution in terms of conducted calibration in an orchard in which the test was performed. For the next production season, it is necessary to adjust the model of calibration in the same orchard for increasing development and rise of the crown. Research shows that in the given testing conditions with calibration losses can be reduced due to the spray drift on soil for 26.44%, and spray drift in air for 2.50%. Presumptions relating to the reduction of the spray drift in air were not achieved and the reason was the low level of development of the crown and the passage of the material between the crowns of the plants.

The right calibration enables consistent coverage, both in height and depth of the crown. Proper calibration of the sprayer is recommended for all types of developed and breeding orchards, especially young ones where can be achieved significant savings of the material, due to the losses reduction in the form of spray drift. Properly performed calibration of the device allows you to select the optimal mode that results high quality application with lower standards while aim that biological effect remains the same or similar. The advantage of the application of calibrated sprayer is reflected in the protection of the environment and the reduction of human and machine work.

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UTICAJ KALIBRACIJE I PODEŠAVANJA ATOMIZERA SAVREMENE KONCEPCIJE NA KVALITET APLIKACIJE

SAŽETAK

U radu su prikazani rezultati eksploatacionih ispitivanja novog, savremenog i visokopreciznog vučenog atomizera u poljskim uslovima pri tretiranju mladog zasada jabuke. Zadatak ispitivanja je utvrditi stvarne gubitke radne tečnosti usljed neadekvatne podešenosti i dati smjernice prema uslovima tretiranja za smanjenje istih. Ispitivanja imaju zadatak utvrditi optimalni režim rada koji omogućava smanjenje drifta, kako vazdušnog tako i zemljišnog, a smim tim minimizirati gubitak zaštitnog sredstva van tretirane zone. Cilj istraživanja je povećati efikasnost kroz povećanje distribucione efikasnosti i preciznosti samog uređaja. Pri istraživanju je evidentirana norma tretiranja od 520 *l/ha,* dok je prosječna pokrivenost krune iznosila 35,29 %. Pri toj normi evidentirani su gubici radne tečnosti od 17,21 % u obliku vazdušnog drifta i 34,98 % u obliku zemljišnog drifta. Nakon kalibracije, baždarenja i podešavanja atomizera ostvarena je prosječna pokrivenost krune od 38,05 % uz normu tretiranja od 290 *l/ha*. Pri umanjenoj normi gubici u obliku zemljišnog drifta iznose svega 8,56 %, a vazdušnog 14,71 %, tj. pokrivenost pločica koje mjere gubitke je znatno smanjena.

Rezultati ispitivavanja ukazuju na gubitke koji se javljaju usled zemljišnog i vazdušnog drifta, a koji su jako izraženi kod mladih zasada kod kojih je kruna slabo razvijena. Značajno je istaći da je pri ovom istraživanju u mladom intenzivnom zasadu norma tretiranja sa 520 *l/ha* smanjena na 290 *l/ha* uz zadržavanje kvaliteta pa i uz blago poboljšanje sa aspekta pokrivenosti same krune, a tim i efikasnosti zaštite. Rezultati ispitivanja pokazuju da i pored primjene savremenih i skupih koncepcija atomizera usljed loše podešenosti istih, dolazi do izraženih gubitaka u obliku drifta. Navedene probleme je moguće smanjiti na minimum uz adekvatno podešavanje kroz kalibraciju i baždarenje samog uređaja.

Ključne riječi: kalibracija, baždarenje, aplikacija, drift, gubici