Characteristics crop plants in the aspect of the process of spraying

Charakterystyka opryskowa roślin w aspekcie procesu opryskiwania

PhD Student Eng. Beata Cieniawska, Prof. Assoc. Deta Łuczycka, Prof. Assoc. Antoni Szewczyk
Wrocław Univeristy of Environmental and Life Sciences, Institute of Agricultural Engineering, Poland
e-mail: antoni.szewczyk@up.wroc.pl

Abstract: Pesticides used in agriculture during chemical plant protection against pests pose a significant threat to the environment. Pesticide should be characterized by: high toxicity in relation to pests and low toxicity compared to other organisms, adequate durability and high susceptibility to degradation. In practice, the achievement of these goals is often impossible. The aim of the study was, therefore, to use a parametric characterization of sprayed plant in the aspect of the process of spraying. In order to do this study the degree of coverage of sprayed objects using selected nozzles assessing which of the tested nozzles has the best properties in terms of covering horizontal and vertical surfaces sprayed plants. In the second part of the study was performed parametric characteristics selected for plant research at the surfaces of vertical and horizontal projections and ratio settings sprayed surface.

KEYWORDS: SPRAYING, PARAMETRIC CHARACTERIZATION OF PLANTS, THE DEGREE OF COVERAGE

1. Introduction

Contemporary agricultural production which is in the stage of strong development as well as intensification of production. It is described by the growth of the use of artificial industrial agrochemicals, including pesticides. Nowadays they guarantee the high quality and quantity of crops (Nieróbca i wsp. 2010). The use of plant health products is the basis of protecting plants from pests. The situation will not change in the near future as there is no method which would substitute the present one, and without the use of pesticides the value of crops will drop dramatically. Moreover the change of plant health programs being in use would require significant amount of financial investments (Pruszyński, 2010). Among the priorities in terms of using plant health products are: the high quality of plant protection treatments, improved efficiency, elimination of any threat to the environment as well as people protecting the plants (Oerke i wsp. 1994; Őzkan 2008; Pruszyński 2003; Szewczyk 2002; Szewczyk 2010a). That is why a lot of attention in the literature of the subject has been paid to the issue of proper chemical plant health treatment. So far one of the most important aspects of the atomization process, which is the characteristics of the sprayed object in terms of its morphology or an even more important feature - the degree of the sprayed area's exposition to the stream of liquid sprayed by the nozzle, has not been considered. That is why a two-stage research has been carried out at the Institute Agricultural Engineering at Wrocław University of Environmental and Life Sciences. Its aim was to present the degree of the sprayed objects' covering in terms of characteristics of sprayed plants in outdoor cropping

2. Material and methods

The research was carried out in laboratory conditions at a specially prepared site used for examining the plants' surfaces.

The scheme of the test site is displayed in figure 1. The examined plant was put in a measurement chamber on a turntable. Next, the photos of horizontal and vertical projections were taken. The camera that was used for taking the photos of horizontal surfaces of the plants was placed inside the chamber, with the ability to move it vertically (up-down) - the smaller the plant, the lower the position of the camera. The other one that was used for taking the photos of vertical surfaces of the plants was placed in front of the measurement chamber on an inclined plane. It allowed the camera to be moved horizontally (forward - backward), depending on the plant's size - the smaller the plant, the closer the camera's position. The distance between the camera and the plant did not matter as it was the plants' surfaces ratio that was put for further analysis, and not the absolute value. The vertical surface photos of the plants were taken six times, thanks to the turntable which allowed the 60° rotation. In order to guarantee the best lightning condition in the chamber, LED battens were put on aluminium profiles. During particular acquisitions, some of the lights were switched off so as no to make the exposition glare. (fig 2).

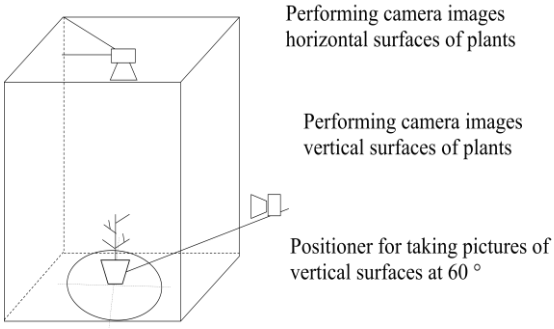

Fig. 1 The scheme of the test site

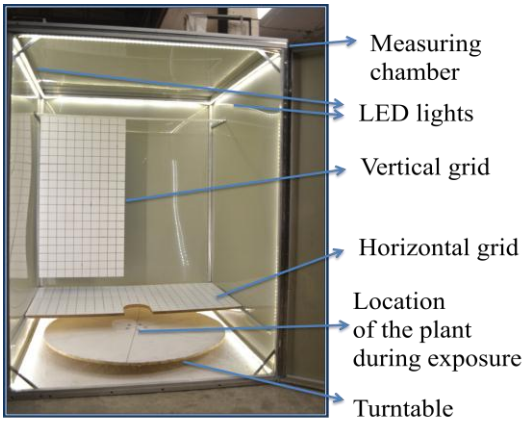

Fig. 2 General view of the site.

The acquisition of the vertical surfaces was made against the background of a vertical grid moved on a guide. The background for the horizontal photos on the other hand was a horizontal grid. One side of the grid's square was 5 cm long as it was a required condition allowing to create a graphic analysis in AutoCad 2011. The analysis in this program allowed to calibrate the photos that had been taken. The program chosen by the authors is the tool that ensured reaching all goals that were set during the processing of the photos.

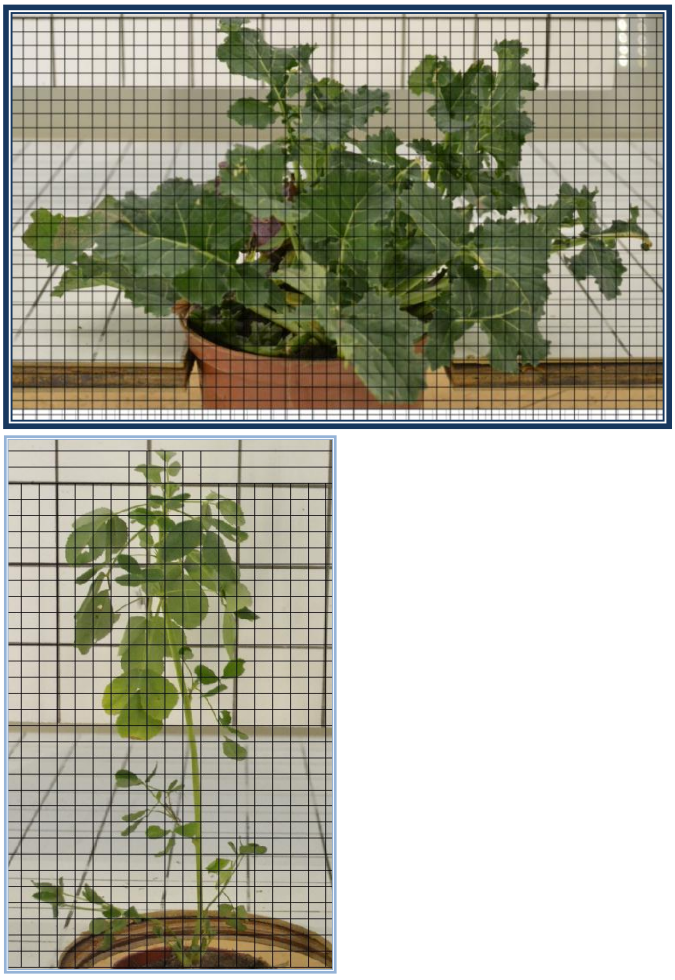

Fig. 3. The photos of vertical projections

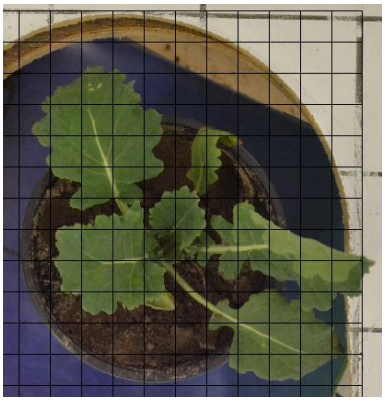

Fig. 4 The photos of horizontal projections

The following plants were chosen for the tests: a lucerne, a rape in the stage of forming its rosette, a rape in the stage of elongation of its shoots, a rape in the stage of falling flowers, forming its shucks and a beetroot in the stage of forming its rosette.

After receiving the results of the graphic analysis in AutoCad 2011 the modulus of the sprayed surfaces was calculated. It was done by the use of the following formula that included the vetical and horizontal projections of the sprayed surfaces ratio.

$$W_{po} = \frac{the\ surface\ of\ vertical\ projections}{the\ surface\ of\ horizontal\ projections}\ [-]$$

The site used for testing the degree of covering was described in the authors' publication (Szewczyk i in. 2012).

3. Results and discussion

The results of the testing the spray characteristics were displayed on the graphs below (fig. 5 – 9). They present five repetitions of the surfaces' measurements results obtained for five kinds of plants differing essentially in their morphological features.

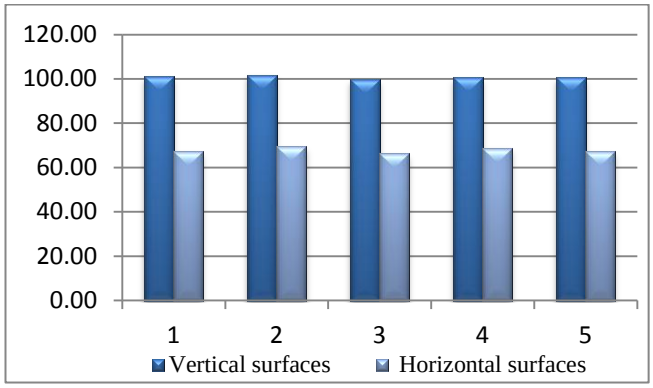

Fig. 5. Projections area horizontal and vertical lucerne

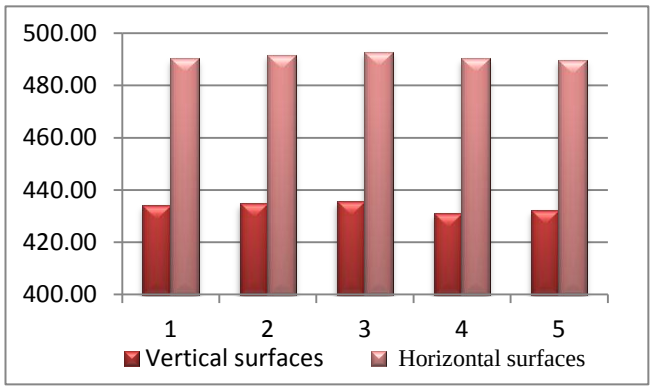

Fig. 6. Projections area horizontal and vertical rape in phase elongation shoot

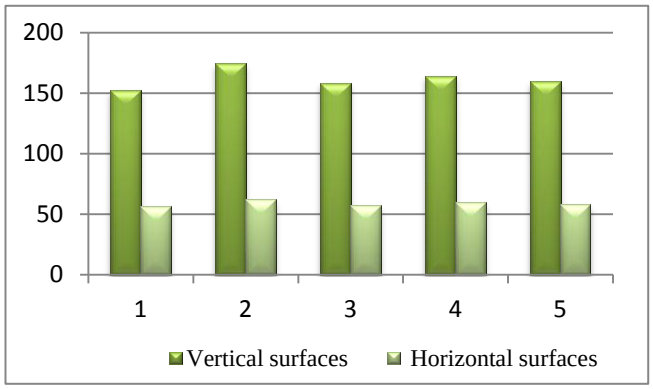

Fig. 7. Projections area horizontal and vertical rape in phase fall flower petals

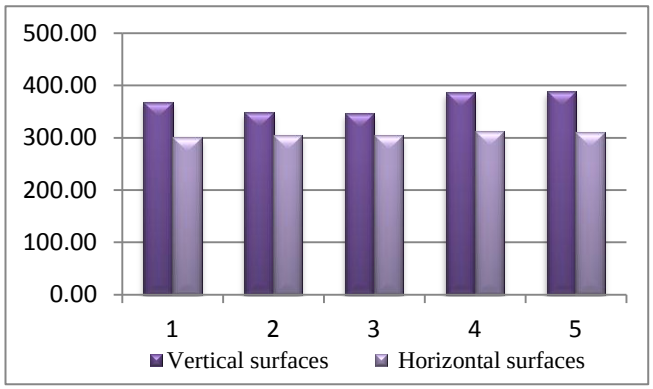

Fig. 8. Projections area horizontal and vertical beet in phase forming rosette

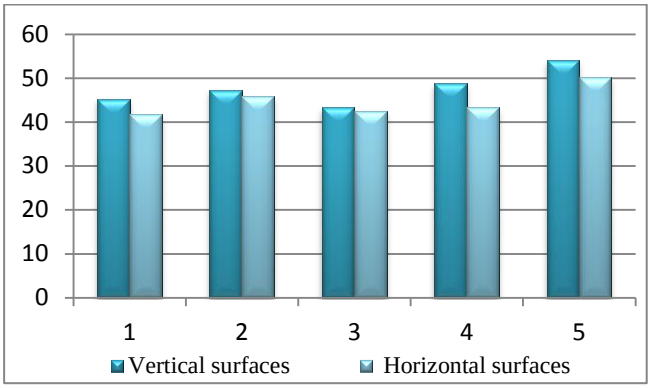

Fig. 9. Projections area horizontal and vertical rape in phase forming rosette

Table 1 presents the values for the modulus of the sprayed surfaces' location. The plants with bigger surface of horizontal projections than its vertical projections (a lucerne, a rape in the stage of falling flower petals, a beet in the stage of forming its rosette, a rape in the stage forming rosette) – the modulus was bigger than 1. In the case of the rape in the stage of elogation of its shoots, where the surface of vertical projections was smaller than the surface of horizontal projections- the modulus was lesser than 1.

Table 1. The results of the modulus of the sprayed surfaces' location

Lucerne	Rape in phase elongation shoot	Rape in phase fall flower petals	Beet in phase forming rosette	Rape in phase forming rosette
1,50	0,89	2,71	1,23	2,20
1,46	0,88	2,81	1,14	2,47
1,50	0,88	2,76	1,14	2,42
1,46	0,88	2,75	1,24	2,22
1,49	0,88	2,74	1,25	2,19

The usefullness in the technique of plants' protection of the presented modulus of the sprayed surfaces' location (chart 2) was widely discussed by the authors in the published materials (Łuczycka i in. 2013).

A lot of books about examining the characteristics of plants show the interest of scientists in the issue discussed in this article. Among the main topics in that area are: determining the photosynthetic surface of plants with the use of video-computer method (Kiełbasa i Juliszewski 2005), determining the influence of the mixed nitric fertilization on the crops, and the indluence of the chemical protection of plants in conditions of varied cultivation systems (Andruszczak i in., 2012; Gołębiowska i Sekutowski, 2007), as well as research concerning the rate of the level of leaflage: LAI – the surface of leaves and MTA – the angle of leaves' gradient (Biskupski i in. 2007; Biskupski i in. 2009;

The double-stream nozzles are better than one-stream ones when it

Woźniak 2008). However, these methods cannot be used for experiments connected with applying plant health products as they do not refer to the surface projections of the plants that are the main target of the drops of liquid sprayed by the nozzle. It is related with the fact that during such treatment the sprayed surfaces are "seen" by the nozzle as a vertical or horizontal projection.

Ejector nozzles (one-stream CVI and double-stream CVI TWIN) were chosen for the research on the coverage degree of the sprayed objects. The results of the research on the coverage degree of particular surfaces were presented in fiures 10 and 11.

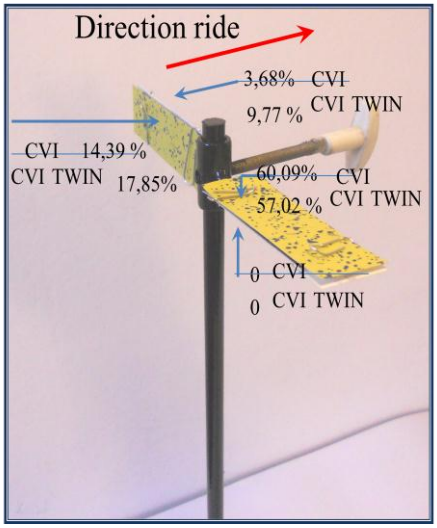

Fig. 9. Coverage degree of vertical and horizontal objects for selected type nozzles, 4 km/h

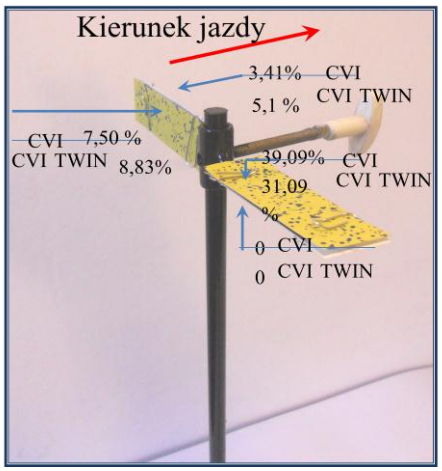

Fig. 10. Coverage degree of vertical and horizontal objects for selected type nozzles, 12 km/h

Figure 9 presents the results of the research on the coverage degree of the sprayed objects at the ride speed of 4 km/h, and figure 10 presents the results for the speed of 12 km/h. The coverage degree of horizontal surfaces was higher with the use of the CVI nozzle. On the other hand, the CVI TWIN use resulted in receiving higher values during the sprayed of vertical surfaces.

comes to covering both vertical surfaces at the same time, regardless of the ride speed. In the course of all the measurements taken during the research, no trace of covering the bottom horizontal objects was ascertained. A lot of authors indicate that the choice of the correct nozzle is an important aspect in plant protection on fields as well as in the gardens or indoors. (Guler i wsp. 2007; Kierzek 2007; Tadel 2007; Kierzek i Wachowiak 2009).

4. Conclusion

1. The analysis of the results of the research on the coverage degree of sprayed objects obtained with the use of select nozzles showed big differences in the coverage of horizontal and vertical surfaces.
2. On the basis of received results and their analysis we can state that the characteristic feature of the examined nozzles is the different range of the coverage degree of vertical and horizontal surfaces. One-stream nozzles are better at covering upper horizontal surfaces while double-stream nozzles are better at covering vertical surfaces.
3. The surface of horizontal and vertical projections and the rates of sprayed surfaces are parametres in which the examined palnts differed most.
4. The W_{po} factor determining the mutual ratio of the sprayed surfaces makes it easier to make the right choice of the nozzle used for protecting plants when it comes covering the sprayed plants with liquid as efficiently as possible.

The project is co-funded by the European Union under the European Social Fund.

5. Literature

Andruszczak S., Kwiecińska-Poppe E., Kraska P., Pałys E. 2012. Wpływ niektórych środków ochrony roślin na kształtowanie powierzchni liści i kąta ich nachylenia u wybranych odmian ozimych pszenicy orkisz (Triticum aestivum ssp. spelta L.). Postępy w ochronie roślin / Progress in plant protection. 52. 1: 163-166.

Biskupski A., Kaus A., Włodek S., Pabin J. 2007. Zróżnicowane nawożenie azotem a plonowanie i wybrane wskaźniki architektury łanu kilku odmian pszenicy jarej. Inżynieria Rolnicza. 91. 3: 29-36.

Biskupski A., Włodek S., Pabin J. 2009. Wpływ zróżnicowanej uprawy roli na wybrane wskaźniki architektury łanu oraz plonowanie roślin. Fragmenta Agronomica. 26. 4: 7-13.

Gołębiowska H., Sekutowski T. 2007. Ocena selektywności herbicydów stosowanych w monokulturze kukurydzy z wykorzystaniem wskaźnika powierzchni liści (LAI) i kąta

nachylenia liści (MTA). Inżynieria Rolnicza. 91. 3: 51-58.

Guler H., Zhu H., Özkan H.E., Derksen R.C., Yu Y., Krause C.R. 2007. Spray characteristics and drift reduction potential with air induction and conventional flat-fan nozzles. Transactions of the ASABE. 50(3): 745−754.

Kierzek R. 2007. Skuteczna ochrona roślin [cz. II]. Dobór rozpylaczy do zabiegów polowych. Ochrona Roślin. 1. 52: 32–35.

Kierzek R., Wachowiak M. 2009. Wpływ nowych typów rozpylaczy na jakość pokrycia roślin ziemniaków cieczą użytkową. Prog. Plant Prot./Post. Ochr. Roślin. 49. 3: 1145–1149.

Nieróbca A., Zaliwski A., Horoszkiewicz-Janka J. 2010. Rozwój internetowego systemu wspomagania decyzji w ochronie zbóż. Inżynieria Rolnicza 7(125). s. 167–173.

Łuczycka D., Szewczyk A., Cieniawska B. 2013. Ocena jakości opryskiwania w literaturze przedmiotu. Materiały Konferencyjne Racjonalna Technika Ochrony Roślin. 112-123.

Oerke E.C., Dehne W., Schönbeck F., Weber A. 1994. Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops. Elsevier Science. ISBN 0444820957.

Özkan H. E. 2008. Technological Solution to Problems Associated with Application of Pesticides Jor. Of Agricultural Machines Sciences 4(2), s. 193-198.

Pruszyński S. 2003. Ochrona roślin – spojrzenie w przyszłość. Racjonalna Technika Ochrony Roślin. Mat. Konf. s. 5-16.

Pruszyński S. 2010. Stan obecny i przewidywane kierunki zmian w ochronie roślin do 2020 roku. Studia i raporty IUNG – PIB. Puławy 14: 207-242.

Szewczyk A., 2002. The impact of sprayer work parameters on field beam position in a vertical plane for some tractor-attached sprayers. Maintenance and Reliability PAN Lublin. Nr 3(15). s. 13–18.

Szewczyk A. 2010. Analiza ustawienia, parametrów i warunków pracy rozpylacza w aspekcie jakości opryskiwania upraw polowych. Wydawnictwo Uniwersytetu Przyrodniczego we Wrocławiu. ISSN 1898-151.

Szewczyk A., Łuczycka D., Cieniawska B., Rojek G. 2012. Porównanie stopnia pokrycia obiektów opryskiwanych wybranymi rozpylaczami eżektorowymi – jedno i dwustrumieniowym. Inżynieria Rolnicza. Nr 2 (136). s. 325-334.

Tadel E. 2007. Technika ochrony polowych upraw wysokich ze szczególnym uwzględnieniem kukurydzy. Mat. Konf. Racjonalna Technika Ochrony Roślin. 100-106.

Woźniak A. 2008. Wpływ zróżnicowanego udziału pszenicy jarej w zmianowaniu na indeks powierzchni liści (LAI). Acta Agrophysica. 12. 1: 269-276.