Scientific Papers. Series A. Agronomy, Vol. LXI, No. 1, 2018
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ESTIMATION OF THE LIQUID COVER OF SELECTED DICOTYLEDONOUS PLANTS IN VARIOUS PHASES OF DEVELOPMENT DURING SPRAYING

Beata CIENIAWSKA, Deta ŁUCZYCKA, Antoni SZEWCZYK, Katarzyna DEREŃ

Institute of Agricultural Engineering, The Faculty of Life Sciences and Technology, Wroclaw University of Environmental and Life Sciences, ul. Chełmońskiego 37A, 51-630 Wrocław, Poland

Corresponding author email: beata.cieniawska@upwr.edu.pl

Abstract

Chemical method of plant protection is an indispensable part of modern agriculture. Researchers emphasize the importance of properly spraying, but the characteristics of the sprayed plants are not taken into account during the experiment. A study was conducted in order to estimation of the liquid cover of selected dicotyledonous plants in various phases of development during spraying. The research was carried out in laboratory conditions at a specially prepared site used for examining the plants` surfaces. On the basis of the carried research, as well as its analysis, we can ascertain that taking into consideration the characteristic sprayed surface of plant makes it much easier to choose the right nozzle for spraying.

Key words*: spraying, degree coverage, estimation liquid cover.*

INTRODUCTION

In modern agriculture, the most important is to achieve the highest yields. Achievement this goal, it is necessary to perform chemical methods of plant protection. However, the spraying carried out improperly may contribute to a reduction in the effectiveness of plant protection products and may cause the need to repeat the treatment. Additionally, the spray liquid can be drifted to an area that was not the target of the treatment and cause environmental pollution (Gil et al., 2013; Reimer, Prokopy, 2012). The spraying procedure is the most effective when the spray liquid covers the largest area of the plant (Ferguson et al., 2016). Many researchers emphasized that the choose of appropriate technical and technological parameters, the use of appropriate nozzles, as well as the use of adjuvants and control of meteorological conditions in real time determine the correct course of the spraying operation (Derksen et al., 2014; Doruchowski et al., 2017). So far, the spray characteristic of plants has not been taken into account during the spraying. However, methods available for assessing plant characteristics, eg. LAI, MTA, fAPAR, phenological phase of the plant life cycle, do not define the characteristics and parameters of plants directly related to the spraying process (Feng et al., 2013; Savoy, Mackay, 2015). Therefore, the present research, carried out at the Institute of Agricultural Engineering of the University of Life Sciences in Wrocław, aimed estimation of the liquid cover age of selected dicotyledonous plants in various development phases.

MATERIALS AND METHODS

Research carried out in laboratory conditions, in the two stages. The first part of the research was concerned with determining the sprayed surface. The measurement stand is patent-protected. The scheme of measurement stand is shown in Figure 1. The main element of the measurement stand was the measuring chamber, in which photographs of the surface of horizontal and vertical projections were taken. The plant was placed on turntable. Photographs of horizontal surface were made over the plant. Photos of vertical surface were made before the plant. Photographs of vertical surfaces were made six times, after rotation of the plant on the turntable by 60°.The distance of the camera from the plant was the same, while the lens with a variable focal length was used. The measuring chamber has been equipped with additional lighting in the form of LED. The measuring chamber was fitted with vertical and horizontal meshes which the backgrounds of the pictures were taken. Area 1 of the square was 25 cm^2.

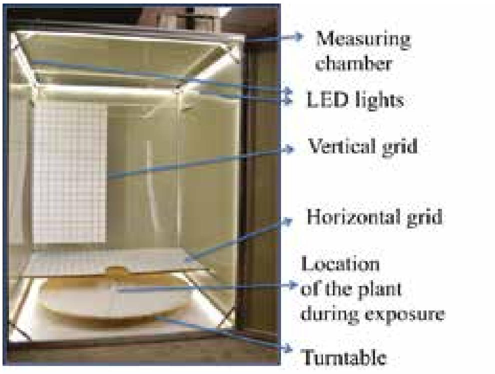

Figure 1. Measurement stand

Calculations of the surface of vertical and horizontal projections were carried out in the graphic program. After the graphical analysis of the photos, the position of the spray surfaces was calculated according to the following formula:

$$Wpo = \frac{projection\ vertical\ surfaces}{projection\ horizontal\ surfaces}\ (\text{-})$$

Five samples of sugar beets and potatoes in four development phases were used for the research.

In the second stage of the research, the degree of coverage of horizontal and vertical surfaces was determined using four nozzles single standard flat-fan (XR 11002), single air-induction flat-fan (CVI 11002), twin standard flat-fan (DG TJ60 11002), and twin air-induction flat-fan (CVI TWIN 11002). The scheme of the research position is presented in Figure 2. The primary element of the measurement stand was the nozzles' carrier. The nozzles' carrier functioned as a carrier itself. The driving speed was 2.2 $m \cdot s^{-1}$ and the liquid pressure was 200 k Pa.

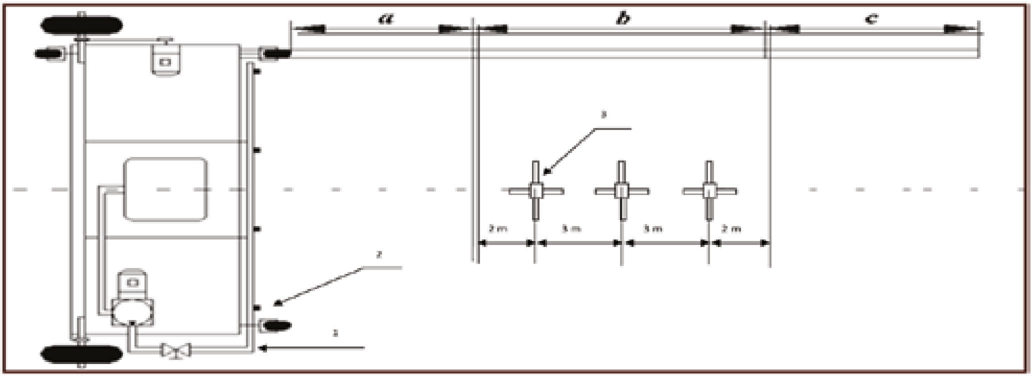

Figure 2. Schematic representation of the measurement stand: a - run line; b - a measurement line; c - ending line; 1 - nozzles carrier; 2 - nozzles; 3 - an artificial plant

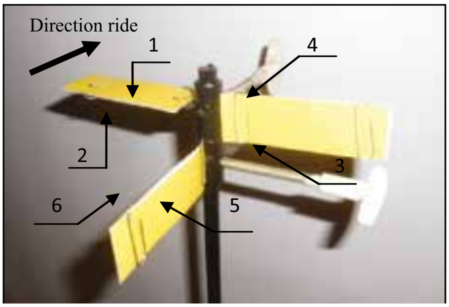

Figure 3. Photo of an artificial plant: 1 - upper level (Apog); 2 - lower level (Apod); 3 - vertical approach (Anj); 4 - vertical leaving (Aoj); 5 - vertical right (Apr); 6 - vertical left (Al)

The sprayed objects were artificial plants with attached WSP probes (Figure 3). The coverage degree of the examined objects was determined by the computer image analysis. Three representative fragments of the surface with 10 x 10 mm dimension were chosen on the probe's area, and then the program read the value according to the formula:

$P_{sp} = \frac{W_k}{W_p} * 100[\%]$ where:

P_{sp} - coverage degree [%];

W_k - surface covered with liquid [pixels];

W_p - 1 cm^2 surface [pixels].

In order to estimate the coverage of selected crop plants, total coverage was calculated on objects determined by product the sum of the surface of the horizontal and vertical projections of a given crop in a given development phase by the sum of the average coverage of the spray liquid horizontal and vertical objects.

$$P_c[cm^2] = \frac{[A_{hs}[cm^2] * P_{shs}[\%]] + [A_{vs}[cm^2] * P_{svs}[\%]]}{100}$$

where:
P_c - total coverage;
A_{hs} - area horizontal surfaces;
P_{shs} - degree coverage horizontal surfaces;
A_{vs} - area vertical surfaces;
P_{svs} - degree coverage vertical surfaces.

RESULTS AND DISSCUSSIONS

The spray characteristics of the sugar beet on the BBCH 14, 18, 31, 36 scale and potatoes on the BBCH 10, 30, 39, 67 scale are compiled in Table 1. Based on the analysis of the obtained data, it can be concluded that the sugar beets in the BBCH 14 and 36 development phase had a larger surface area of horizontal projections compared to vertical projections, opposite of the BBCH 31 scale, when the area of horizontal projections was the larger share area. A similar value of the surface of horizontal and vertical projections was characterized by sugar beets in phase 18 of the BBCH scale. On the other hand, potatoes were characterized by a larger share area of the surface of horizontal projections. With the growth of the plant, the area of the crops of the analyzed plant increased.

Table 1. Characteristic plant

Crop	Development phase	Area of vertical projections $[cm^2]$	Area of horizontal projections $[cm^2]$	W_{po} [-]
Sugar beet	BBCH 14	32.50	64.20	0.51
	BBCH 18	415.99	349.27	1.19
	BBCH 31	1470.34	612.90	2.40
	BBCH 36	2499.68	3467.60	0.72
Potato	BBCH 10	68.70	110.60	0.62
	BBCH 30	167.58	313.18	0.54
	BBCH 39	370.08	492.44	0.75
	BBCH 67	2100.86	2157.80	0.97

Results of the research on coverage degree of vertical and horizontal surfaces with the used selected nozzles presented on Figure 4. The highest value coverage vertical surfaces noticed for twin standard flat-fan DF 12002, while the highest value coverage of horizontal surfaces obtained for single standard flat-fan XR 11002. Taking into consideration air injection nozzles, it should be noted that cover horizontal and vertical surfaces was the higher values when used single flat-fan CVI 11002. However, the difference in coverage degree equals only 0.31% for vertical surfaces.

The results of the estimation of sugar beet cover during spraying are shown in Figures 5-8. Higher values of sugar beet coverage level on the BBCH 14, 18 and 36 scale would be obtained with a single flat-fan nozzle. However, when spraying sugar beets in the 31 BBCH scale, it would be more beneficial to use the DF 12002 double flat fan nozzles.
The results of the estimation of potatoes cover during spraying are shown in Figures 9-12. Higher values of the degree of coverage of potatoes in the analyzed scales would be obtained in the case of a single flat-fan nozzle.

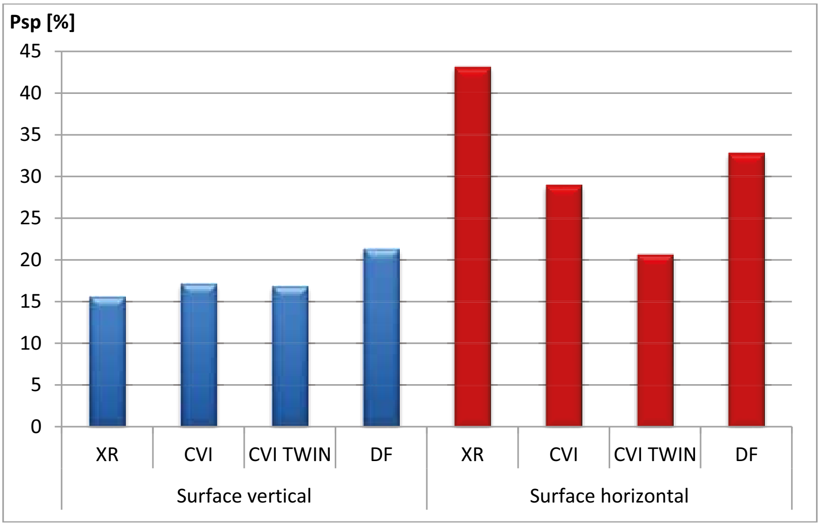

Figure 4. Coverage degree of horizontal and vertical surfaces for selected type nozzles

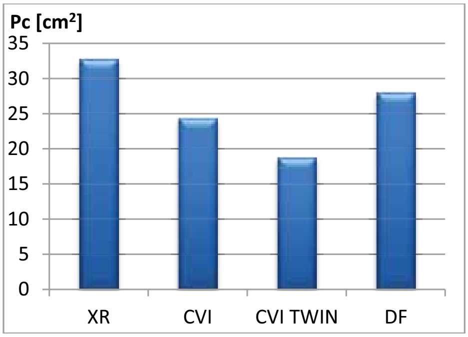

Figure 5. Estimation of the liquid cover beet sugar on the 14 BBCH scale

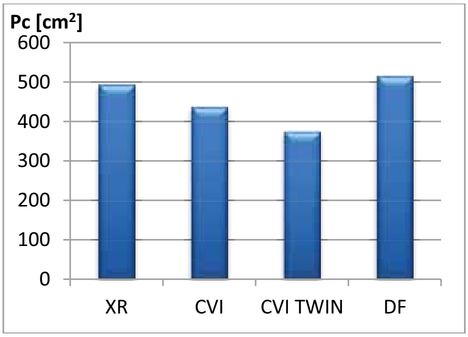

Figure 7. Estimation of the liquid cover beet sugar on the 31 BBCH scale

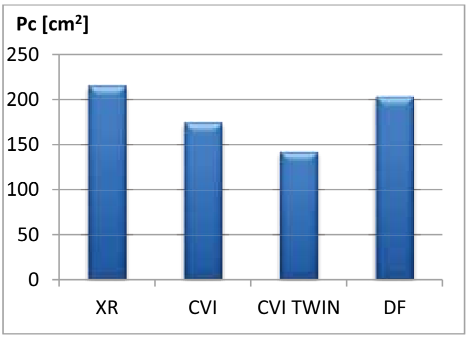

Figure 6. Estimation of the liquid cover beet sugar on the 18 BBCH scale

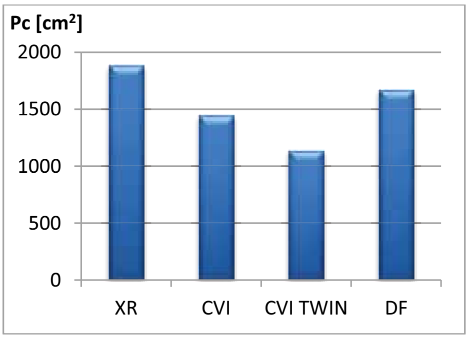

Figure 8. Estimation of the liquid cover beet sugar on the 36 BBCH scale

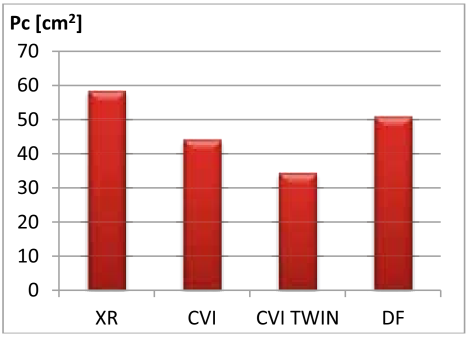

Figure 9. Estimation of the liquid cover potatoes on the 10 BBCH scale

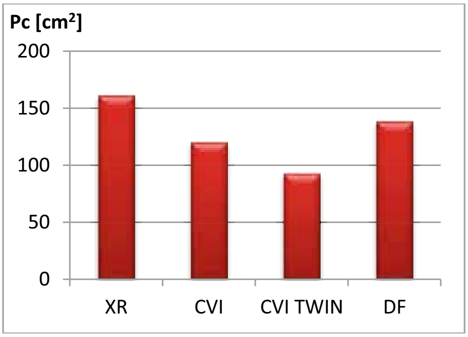

Figure 10. Estimation of the liquid cover potatoes on the 30 BBCH scale

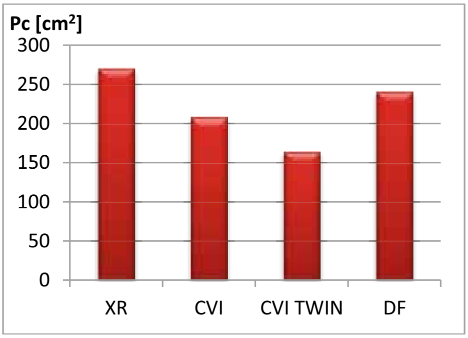

Figure 11. Estimation of the liquid cover potatoes on the 39 BBCH scale

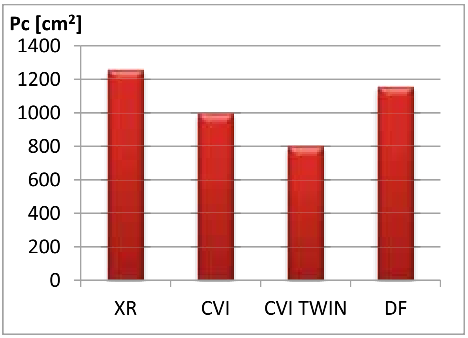

Figure 12. Estimation of the liquid cover potatoes on the 67 BBCH scale

CONCLUSIONS

1. The characteristic sprayed surface of plant and Wpo, that characterizes the sprayed plant and its developmental stage, makes it much easier to choose the right nozzle for spraying.
2. Analysis of the obtained results showed that the coverage depends on the type of nozzle used. Higher values of coverage of horizontal objects were noted using single-flat-fan nozzles. While higher values of coverage of vertical objects were obtained using double flat-fan nozzles.

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