

INVESTIGATIONS OF APPLYING BIOLOGICAL PRODUCT *BIOKALI* ON POTATO CROPS WITH SPECIFIC EQUIPMENT *LECHLER DROPLEG^{UL}* FOR SPRAYING UNDER THE LEAVES OF CULTURAL PLANTS

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The application of insecticides and fungicides on the underside of leaves is performed with a help various technological solutions, seemingly as the application of soil herbicides and liquid mineral fertilizers that are sprayed under the leaves of cultural plants. This task is performed using straight spraying pipes with slit (symmetrical and asymmetrical flow) nozzles, stream conical flow nozzles, or specific curved (e. g. *Lechler Dropleg^{UL}*) nozzles that enable diagonal spraying upwards.

The objective of the research was to identify the potato coverage differences spraying the biological product *biokali* with specific equipment *Lechler Dropleg^{UL}* for spraying the biological product under the leaves and various nozzles.

In earlier stages of potato growth, the specific equipment *Lechler Dropleg^{UL}* and deflection nozzles *Lechler FT 1.0* for spraying the product under the leaves of cultural plants better covers potato stems and the underside of upper leaves. In the control group, where the ultimate slit flat flow nozzles *Hardi ISO F/LD-05-110* were used, droplets of the biological product covered 4.8±1.7 % of potato stem area only, the *Dropleg^{UL}* and three nozzles (*LU-120-02* from the top and two deflection nozzles *Lechler FT 1.0* from the bottom) covered even 55.8±39.1 %. Accordingly, plants of the control group had only 0.1±0.1 % of the underside area of the upper leaves covered with the product, while using *Dropleg^{UL}* and three nozzles such area reached 1.5±1.1 %.

In later stages of potato growth, specific equipment *Lechler Dropleg^{UL}* with deflection nozzles *Lechler FT 1.0* for spaying under the leaves of cultural plants better covered the underside of upper leaves of potatoes only.

The usage of double flow nozzles *Lechler DF-120-02* on *Dropleg^{UL}* and ultimate slit flat flow nozzles *LU-120-02* on a spraying boom gave rather small differences in coverage of the surface compared the control group, where the ultimate slit flat flow nozzles *Hardi ISO F/LD-05-110* were used.

Keywords: application, biological product, nozzles, coverage of surfaces sprayed.

INTRODUCTION

1980 company *Benest* from England developed a sprayer equipped with the pipes able to spray under the leaves of cultural plants. Their technology is known under the names *Benest Dropleg* and *Dropleg Application Distribution System (DADS)*. The lower part of the spraying pipes used is curved backwards so that the nozzle could spray diagonal upwards. The direction of spraying can be adjusted. Various nozzles, e. g. micro drop stream conical flow or six stream, can be mounted on the end of the curved spraying pipe (Rüegg and Total, 2013; Zinkevičius, 2011).

Comparative investigations of *Benest Dropleg* system, performed in England, showed enough good results in potato, grain, and carrot crops. It was identified that the coverage of nozzles spraying upwards is good and only a small amount of the liquid sprayed deposits of a soil. Thus, such system ideally suits for spraying plant protection products in high crops (Kifferle and Stahli, 2001; Wallner, 2014).

Jeffrey and McKinay research show (Kifferle and Stahli, 2001) that the system of *Benest Dropleg* reduces the droplet drift seemingly to the hydro-pneumatic sprayer *Hardi Twin*.

The performance of the specific equipment for spraying under the leaves was investigated in organically grown potato crops in Germany (Heller et al., 2011; Irla et al., 2000; Irla et al., 2001; Kramer, 2013; Neuhoff et al., 2002; Rüegg and Total, 2010, 2011).

German researchers identified that in organically grown potato crops the optimal liquid spraying rate is 400–500 l/ha and work pressure from 7 till 10 bar, while the ground speed of spraying equipment is 4–5 km/h. Coverage of the surfaces sprayed improves using additional air systems, injector type hydro-pneumatic nozzles and equipment for spraying under the leaves (Irla et al, 2000).

In two-year investigation Irla E. et al. (2000) compared technologies for spraying copper preparations in organically grown potato crops (*Agria* species). It was identified, that using specific equipment for spraying under the leaves, potato leaves, first of all their underside, were better covered with the copper preparation. After increasing the spraying rate from 400 till 500 l/ha, the coverage of potato leaves increased from 4 till 37 %. Both, the first and second, year of investigations did not disclose essential differences between the alternatives (hydraulic field sprayer with injector type hydro-pneumatic nozzles vs specific equipment for spraying under the leaves) of reducing the amount of leave rot. The authors of the article did not deliver any data on potato productivity. However, they believe that the consumption of copper preparations sprayed using specific equipment for spraying under the leaves 400–500 l/ha can be reduced by approx. 50 % (Irla et al., 2001) on organically grown potato crops.

Neuhoff D. et al. used Jacoby hydraulic field sprayer equipped with the specific equipment for spraying under the leaves and aggregated with Hege tractor in their experiments. Pesticides were sprayed using hydraulic slit nozzles. The investigations showed that maximum possible coverage of leaves of cultural plants is especially important in organic farming. It was identified that potato leave rot can be reduced by 50 % spraying in a usual manner (i. e. downwards) and upwards (using specific equipment for spraying under the leaves). However, the results of spraying the other preparations were controversial (Neuhoff et al., 2002).

The application of biological products using specific equipment for spraying under the leaves of cultural plants has not been investigated in Lithuania.

The objective of the research – to identify the potato coverage differences spraying the biological product *biokall* using specific equipment *Lechler Dropleg^{UL}* for spraying the biological product under the leaves and various nozzles.

OBJECTS AND METHODS

The object of the research – *Lechler Dropleg^{UL}* for spraying under the leaves of cultural plants with deflection *FT 1.0* or double flow *DF-120-02* nozzles.

The investigation was performed in experimental station of Aleksandras Stulginskis University in 2013. The first spraying was performed using Hardi tractor mounted hydraulic field sprayer, while the second spraying was performed using Amazone tractor mounted hydraulic field sprayer.

In potato crops *Dropleg^{UL}* equipment was located so that one row was sprayed by three nozzles (one from the top and two from the bottom), while the other rows were sprayed in usual manner, i.e. only one nozzle spraying from the top. Usually spraying is performed using ultimate slit flat flow nozzles *Hardi ISO F/LD-05-110* with the capacity of 1.636 l/min. under the pressure of 2 bars. A three-nozzle set was composed as follows: ultimate slit flat flow nozzle *LU-120-02* spraying from the top and two deflection *FT 1.0* or double flow *DF-120-02* nozzles spraying from the bottom. Such sets sprayed out 1.89 l/min under the pressure of 2 bars. The investigations were performed in four shifts. During potato vegetation, the first spraying of the biological product was performed on June 26 around 4 pm under air temperature of 24 °C and wind speed of 3 m/s. The second spraying of the biological product was performed on August 2 around 10 am under air temperature of 17°C and wind speed of 5 m/s.

The deposition of the biological product on various parts of cultural plants was investigated using specific water sensitive paper. In potato crops, pieces of the specific water sensitive paper were fixed to the stem and the upper leaves of plants and below them.

The area covered by droplets of the biological product was identified using raster image manipulation software GIMP.

RESULTS AND DISCUSSION

The analysis of spraying the biological product on potato crops showed that using deflection nozzles *Lechler FT 1.0* on *Dropleg^{UL}* equipment and ultimate slit flat flow nozzles *LU-120-02* on a spraying boom the large amount of product falls on a stem and the underside of the leaves of plants. If in a control group where ultimate flat flow nozzles *Hardi ISO F/LD-05-110* were used the droplets of the biological product covered only 4.8±1.7 % of potato stem area, using *Dropleg^{UL}* equipment and three nozzles it reached even 55.8±39.1 % (Figure 1). Accordingly, in a control group, the biological product covered 0.1±0.1 % of the underside area of upper leaves only, while using *Dropleg^{UL}* and three nozzles it reached 1.5±1.1 %. In a control group, better coverage was observed on the upper side of upper leaves (94.0±0.4 % and 74.5±12.6 % respectively).

The results of the second spraying were a bit different. If in a control group, where ultimate slit flat flow nozzles *Hardi ISO F/LD-05-110* were used, the droplets of the biological product covered 7.8±5.9 % of potato stem area, using *Dropleg^{UL}* and three nozzles it reached 3.6±2.3 % only (Table 1). In a control group, the biological product covered 0.6±0.4 % of the underside of upper leaves, while using *Dropleg^{UL}* and three nozzles it reached even 3.3±2.4 %. In control group much better coverage was observed on the upper side of upper leaves (75.2±5.3 % and 11.6±5.5 % respectively).

The results of the investigation show that using double flow nozzles *Lechler DF-120-02* on *Dropleg^{UL}* equipment and ultimate slit flat flow nozzles *LU-120-02* on a spraying boom almost there were no differences in area covered. If in a control group, where ultimate slit flat flow nozzles *Hardi ISO F/LD-05-110* were used, the droplets of the biological product covered 14.5±2.4 % of potato stem area, using *Dropleg^{UL}* and three nozzles the area reached 12.1±3.3 % (Figure 2). Accordingly, in a control group the biological product covered 0.4±0.3 % of the underside of upper leaves

only, while using *Dropleg^{UL}* and three nozzles it reached 0.3 ± 0.2 %. In a control group better coverage was observed on the upper side of upper leaves (84.5 ± 5.0 % and 80.4 ± 7.8 % respectively).

Table 1. The results of potato coverage investigation after the second spraying of the biological product

Plant parts	Area covered by the biological product (%)	
	Control group (nozzles <i>Hardi ISO F/LD-05-110</i>)	Nozzle <i>LU-120-02</i> and two <i>Dropleg^{UL}</i> units with deflection nozzles <i>Lechler FT 1.0</i>
Stem	7.8 ± 5.9	3.6 ± 2.3
Upper side of the upper leaves	75.2 ± 5.3	11.6 ± 5.5
Underside of the upper leaves	0.6 ± 0.4	3.3 ± 2.45

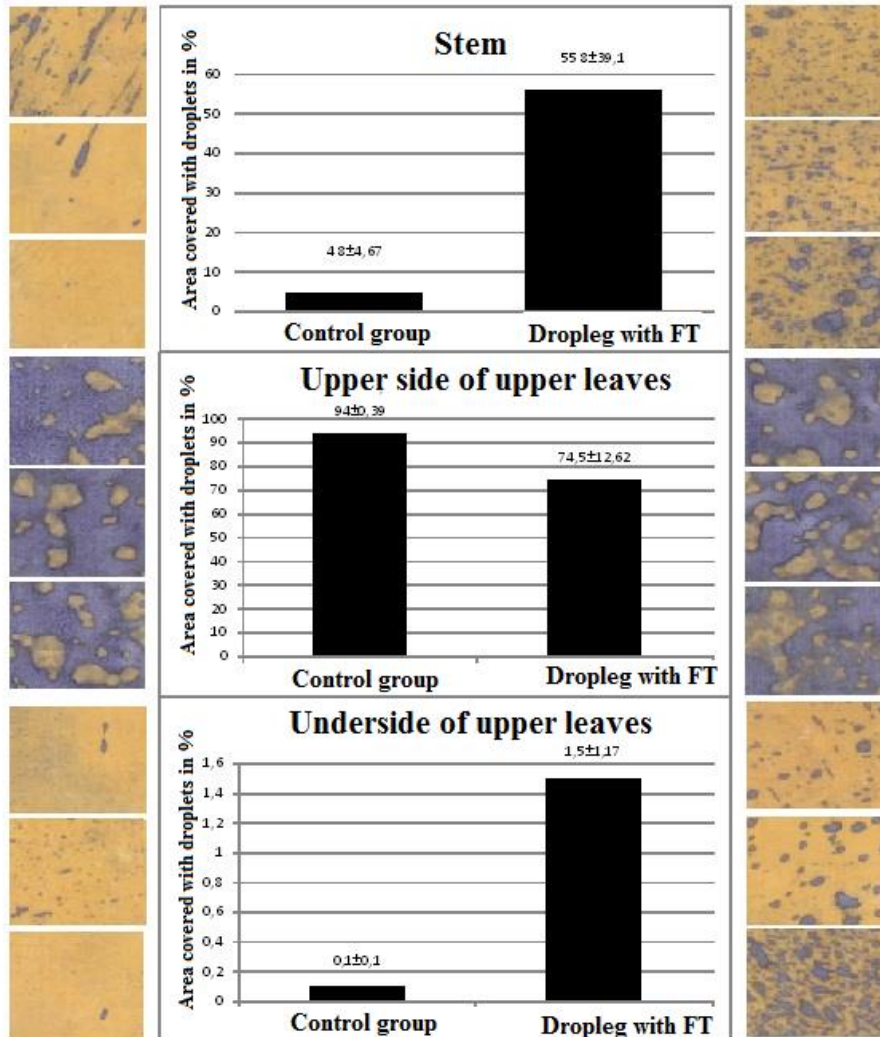


Figure 1. The results of potato coverage investigation: the control group was sprayed using ultimate slit flat flow nozzle *Hardi ISO F/LD-05-110*, the other group was sprayed using nozzle *LU-120-02* from the top and two deflection nozzles *Lechler FT 1.0* from the bottom

The comparison of three nozzle sets (ultimate slit flat nozzle *Lechler LU-120-02* from the top and two deflection nozzles *Lechler FT 1.0* or double flow *Lechler DF-120-02* from the bottom) with each other allows maintaining that potato stems and the underside of upper leaves are better covered with biological products using deflection nozzles.

Using deflection nozzles *Lechler FT 1.0* the biological product covered even 55.8 ± 39.1 % of potato stem area. Using double flow nozzles *Lechler DF-120-02* the droplets of the biological product covered 12.1 ± 3.3 % of potato stem area only which was 4.6 times less. The upper part of potato leaves was covered enough good using various nozzle sets: 80.4 ± 7.8 % (ultimate slit flat flow nozzle *Lechler LU-120-02* from the top and two deflection nozzles *Lechler FT 1.0* from the bottom) and 74.5 ± 12.6 % (ultimate slit flat flow nozzle *Lechler LU-120-02* from the top and two double flow nozzles *Lechler DF-120-02* from the bottom). While using double flow nozzles *Lechler DF-120-02* the biological product covered 0.3 ± 0.2 % of the underside of upper potato leaves area only. Using deflection nozzles *Lechler FT 1.0* the droplets of the biological product covered 1.5 ± 1.1 % of the underside of upper potato leaves areas, which is even five times less.

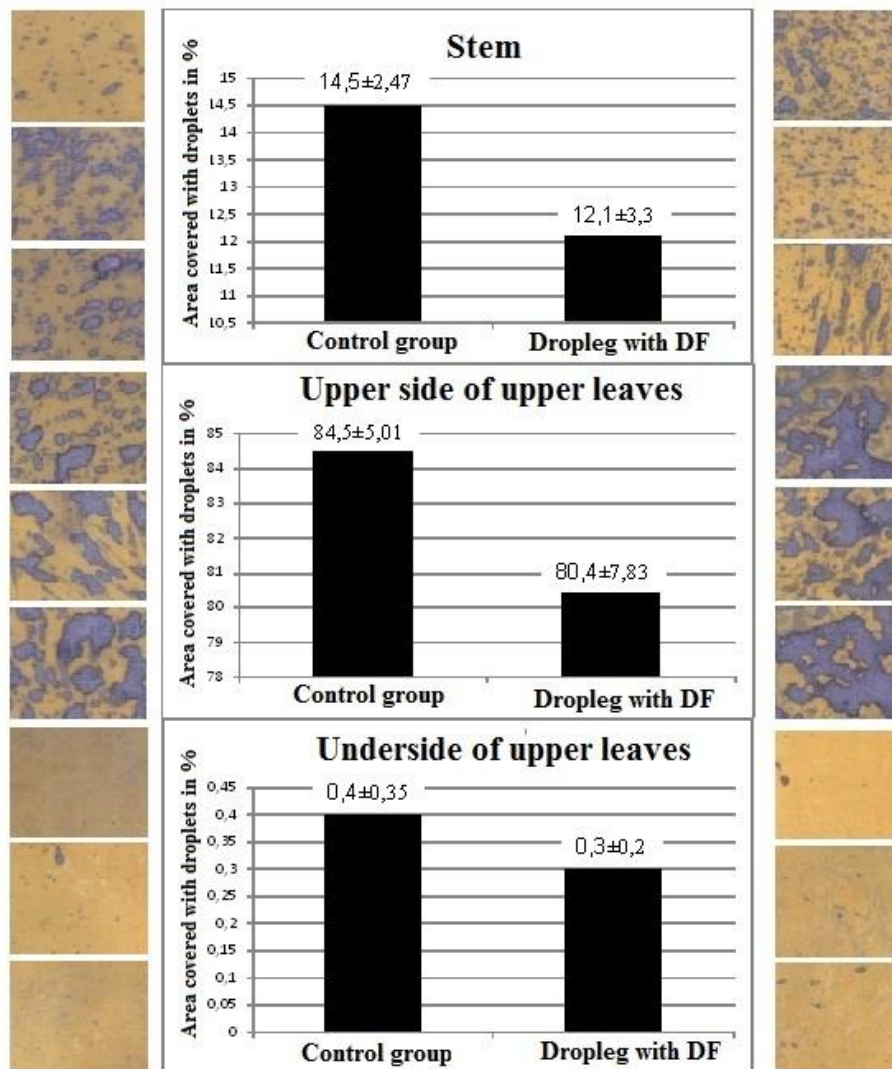


Figure 2. The results of potato coverage investigation: the control group was sprayed using ultimate slit flat flow nozzle *Hardi ISO F/LD-05-110*, the other group was sprayed using nozzle *LU-120-02* from the top and two double flow nozzles *Lechler DF-120-02* from the bottom

CONCLUSIONS

1. In earlier stages of potato growth, the specific equipment *Lechler Dropleg^{UL}* and deflection nozzles *Lechler FT 1.0* for spraying under the leaves of cultural plants better cover potato stems and the underside of upper leaves: if in the control group, where ultimate flat flow nozzles *Hardi ISO F/LD-05-110* were used, the droplets of the biological product covered 4.8 ± 1.7 % of potato stem area only, using *Dropleg^{UL}* equipment and three nozzles (nozzle *LU-120-02* from the top and two deflection nozzles *Lechler FT 1.0* from the bottom) it reached even 55.8 ± 39.1 %. Accordingly, in a control group the biological product covered 0.1 ± 0.1 % of the underside area of upper leaves only, while using *Dropleg^{UL}* and three nozzles it reached 1.5 ± 1.1 %.
2. In later stages of potato growth, the specific equipment *Lechler Dropleg^{UL}* and deflection nozzles *Lechler FT 1.0* for spraying under the leaves of cultural plants better cover only the underside of upper potato leaves: if in a control group, where ultimate slit flat flow nozzles *Hardi ISO F/LD-05-110* were used, the droplets of the biological product covered 0.6 ± 0.4 % of the underside of upper leaves, using *Dropleg^{UL}* and three nozzles (nozzle *LU-120-02* spraying from the top and two deflection nozzles *Lechler FT 1.0* from the bottom) it reached 3.3 ± 2.4 %. In a control group the biological product covered 7.8 ± 5.9 % of potato stem area, while using *Dropleg^{UL}* and three nozzles it reached 3.6 ± 2.3 % only. In a control group much better coverage was observed on the upper side of upper leaves (75.2 ± 5.3 % and 11.6 ± 5.5 % respectively).
3. Using double flow nozzles *Lechler DF-120-02* on *Dropleg^{UL}* equipment and ultimate slit flat flow nozzles *LU-120-02* on a spraying boom differences in coverage of surfaces sprayed were minor: if in a control group, where ultimate slit flat flow nozzles *Hardi ISO F/LD-05-110* were used, the droplets of the biological product covered 14.5 ± 2.4 % of potato stem area, using *Dropleg^{UL}* and three nozzles (*LU-120-02* from the top and two double flow nozzles *Lechler DF-120-02* from the bottom) the area reached 12.1 ± 3.3 %. Accordingly, in a control group the biological product covered 0.4 ± 0.3 % of the underside of upper leaves only, while using *Dropleg^{UL}* and three nozzles it

reached 0.3 ± 0.2 %. In a control group better coverage was observed on the upper side of upper leaves (84.5 ± 5.0 % and 80.4 ± 7.8 % respectively).

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