EXAMINATION ON THE EFFICACY OF SPRAYING OPERATIONS IN VINE PLANTATIONS

MIKLÓS LÖNHÁRD, BÉLA PÁLYI, ZSOLT TAKÁCS, ELEMÉR VÍGH

University of Pannonia Georgikon Faculty
Department of Agricultural Mechanization
Keszthely, H-8360 Festetics str. 7.
muszaki@georgikon.hu

ABSTRACT
Our investigation was to conduct the measurement of spray losses and efficacy using an air-carrier sprayer *in situ*, that is during the practical work to get reliable scientific data to the common practice in vine plantation. During the end of April to mid August six measurements were taken depending on the developmental stage of vine stocks. To determine the degree of chemical deposition and spray losses, leaf samples were taken, or rough-surface plastic sheets and petri-dishes were used. As a tracer Pyranin-solution were used the deposited active substance of samples were determined in a laboratory using a fluorometer. To measure the chemical's deposition on the upper and lower surfaces of the leaves, water-sensitive test papers were placed onto assigned leaves at each levels. They were evaluated using a computerized image analysis. The evaluation of relations between developmental stage and efficacy of sprayings showed, that the amount of liquid sprayed onto the target surface (that is the foliage) as well as the value of recovery, will mainly be determined by the LAI, which shows the development of the foliage. The recovery values of 55-60 % is considered in the literature as a basis for comparisons, and is in case of traditional axial fan sprayers only acceptable and true, if the foliage is very well developed.

Keywords: plant protection, spraying, air-carrier sprayers, spray losses, efficiency

INTRODUCTION

As regard relations between developmental condition of an orchard, and of efficacy of plant protection sprayings very few scientific work can be found in the literature. Using air-carrier sprayers new application technics like ultra sound sensors or tunnel spraying tests as well as data comparisons are necessary to get informations on chemical losses.
The proper choice of operating characteristics of an orchard spraying as well as the conformity of orchard geometry is a much more difficult task in a vine plantation, than in a field crop. The most important geometrical features of an orchard are greatly influenced by the developmental condition of the stocks.
The main reason of our investigation is however, that most of the farmers still use traditional air-carrier sprayers to protect their vine plantations, since they can not afford buying the more environment-saving, but expensive sprayers. An important task of our investigation was to conduct the measurement *in situ*, that is during the practical work to get reliable scientific data to the common practice in vine plantation.

MATERIALS AND METHODS

A vine plantation sheltered from the wind were chosen for the measurements located in south-west direction in its lengths at the village Monostorapáti, West-Hungary. The orchard is bordered with skirts on its northern and eastern side, having Chardonnay vine stocks in curtain-like cultivation. Its main characteristics: Row distance 3.5 m, plant distance 1.2 m, the height of the plants in full development stage was 240-250 cm, with the

lowest leaves being 50-60 cm from the soil surface. The constant provisions chosen for the measurements were:

- Movement speed of the tractor :7 km/h
- Dosis of spray solution: 300-500 l/ha (depending on plant development)
- Pump pressure: 20 bar
- A nozzle set of type ALBUZ ATR-80 (orange colored)
- A determined carry-air stream
- Wind speed : <2 m/s
- Maximal deviation of wind direction from row direction: 30º

To determine the degree of chemical deposition, leaf samples were taken using a leaf-hole-maker from each of 5 vine stocks („A" - „E") of two tested rows at different levels of the plants from 60, 100, 140 and 180 cm (*figure 1a*.). The summarized size of upper and lower surface of a leaf sample was 18.85 cm^2. When no leaf occurred at the lowest sampling level during the early development stage, artificial holding surface of 18.85 cm^2 were used to replace it. Its material was a rough-surface plastic sheet. Further leaf samples were taken prior to each treatments to determine amount of chemical residues remaining from former treatments. To measure the chemical's deposition on the upper and lower surfaces of the leaves, water-sensitive test papers were placed onto assigned leaves at each levels. They were evaluated using a computerized image analysis. To measure the solution drift by wind and airflow, further samples were taken at the border of the orchard from two rows similar to the other samples. To measure deposition rate on the soil, three test lines were created crossing the rows with a distance of 5 m from each other. 8 plastic petri-dishes were located on each test lines between the rows with a total of 224.88 cm^2 active surface (*figure 1b*.). To determine of drift area as a basis we took the measurement results by FOX et al.(1990). According to them at least 75 % of full amount liquid sprayed out will be deposited on the sprayed area as well as within 6 m beside the border row. As a marker material Pyranin-solution in a concentration of 0.01 % were used during the first three measurements, later on diluted to 0.0033 % when the dosis of spraying solution were increased. The amount of deposited active substance of leaf samples and artificial holding surfaces were determined in a laboratory using a Turner type fluorometer.

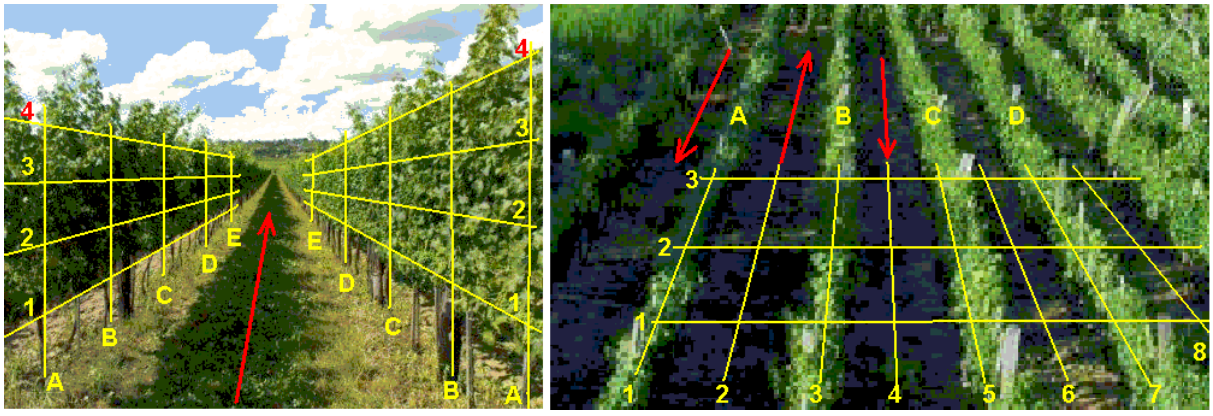

Figure 1. Arrangement of sampling places on the plants(a) and on the soil(b)

For the determination of leaf area index (LAI) and of active substance recovery average sized intact leaves were collected. They were pressed down and their size measured by image analysis.

The following meteorological data were continuously recorded during the investigations: wind direction, wind speed, air temperature, relative humidity, clouds.

RESULTS

To determine the actual value of spraying dosis first we measured the moving speed of Fendt Farmer 209 F engine. In the L/2 gear at 1250 RPM rotary speed of engine, the calculated speed was 6.96 km/h. The rotary speed of cardan-shaft was 345 RPM, this drove the driving mechanism of the axial flow fan of the spraying machine Berthoud BX 1500 Arbo type in its first gear. Albuz ATR 80 type nozzles were mounted onto the holding arch of sprayer machine.

During the end of April to mid August 6 measurements were taken depending on the developmental stage of vine stocks, when 280 l/ha was the spraying dosis in the first three treatments, and 481 l/ha was at the other three treatments.

At the time of the first treatment, on 29th April, the average leaf area was only 7.57 cm^2, the leaf area index (LAI) was 0.23. 6.91 % of the liquid arrived to the target surface, that is onto the leaves, while 12.88 % onto the soil below and between the rows. A minimal amount, 0.08 % got the leaves of the neighbouring rows, and 8.43 % arrived to the soil of neighbouring rows, mainly between the rows. The rest, which amounted to 71.7 %, of the total liquid amount, covered the non-controlled surface, evaporated, or were drifted out of the sprayed area. By using the water-sensitive test papers it proved, that leaf covering was uniform, and similar on the upper and lower side of the leaves, at the 100 cm level, its average covering rate was 13.9 – 40.2 %, while at the higher level (140-180 cm) the upper surface has got higher amount, being covered 33.7 – 98.0 %, and the lower surface 1.7 – 31.6 %. The lower side of some sample became less covered, below the desired minimum rate of 10 %.

At the time of the second treatment (18th May) the LAI was still low, 0.427, consequently the average rate of recovery was 12.92 %, similar value was measured in soil covering to the first measurings, (8.63 % at the sprayed row and 8.23 % at the neighbouring rows. The non-controlled loss still was too high, 69.39 %. The average leaf size amounted to 31.8 cm^2, the leaf covering rate on the upper and lower surface was at the 100 cm and 140 cm level nearly the same, 10, and 46.8 %, and on the highest level the covering of the upper leaf surface again much higher (52.8 -. 81.8 %), than that of the lower surface.

At the time of the third measurement (2nd June) the amount of active substance on the leaf surface (target surface) became much more. The average leaf size was now 90.7 cm^2, the LAI 1.413. The value of recovery was 27.53, which is still below the expected value of a traditional air-carrier axial-fan sprayer. Active substance loss by soil covering below and beside the rows decreased to 6.72 %, while it increased a bit on the neighbouring rows and their soil (1.53 and 6.53 %). The amount of non-controlled loss is still high, 57.7 %.

The data from water-sensitive test papers show, that the upper surface of leaves had higher covering rates (44.4 – 99.7 %) at all leaf levels, than the lower surface (1.2 – 47.0 %. This higher difference is probably due to the fact, that the the air doesn't stir enough the bigger-sized leaves, the moving air pushed the leaves together. This phenomenon is observable also on the dispersion, since traces of smeared liquid can be seen on the leaves (*figure 2*.).

The following measurement continued when the farmer increased the liquid volume per hectare. In contrast to the earlier amount of 289 l/ha, the calculated amount became 481 l/ha. This higher value could be achieved by mounting two other nozzles, therefore the other earlier operating factors (like pump pressure, fan RPM, moving speed) remained constant.

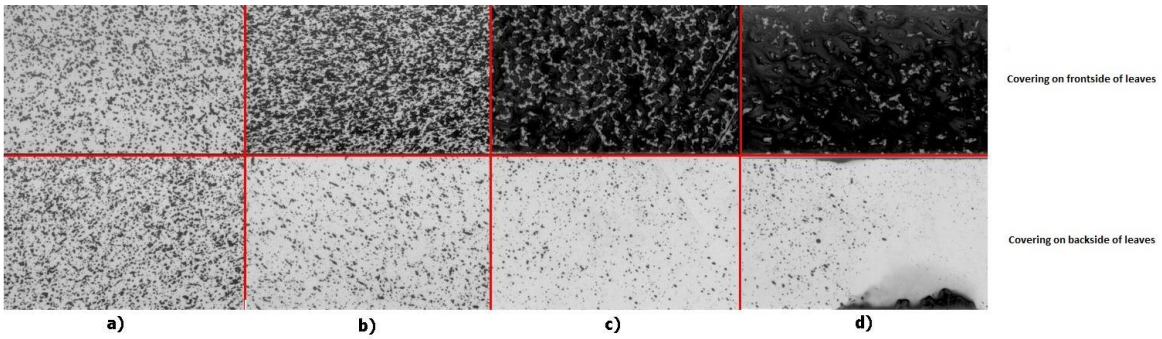

Figure 2. Water-sensitive papers from measurings

a) 29th April, A/1 plant, 100 cm height
b) 29th April, A/3 plant, 180 cm height
c) 2nd June, A/3 plant, 100 cm height
d) 2nd June, A/3 plant, 180 cm height

At the time of fourth measurements (18th June) the LAI increased to 1.658, which was not much more than in the case of the previous treatment. The recovery became nearly 40 %, but also the rate of active substance on the soil also increased to 12 % in the sprayed row, and to 9.27 % out of the row. The amount of active substance on the neighbouring two rows was 2.2 % in relation to the full liquid amount discharged. From these data it can be concluded, that the bigger foliage had a breaking effect on the carry-air, a part of the non-controlled loss appeared at the neighbouring rows, mainly on the soil. Still, 36.66 % of the liquid moved onto non-controlled surface, out of the field of measurements, or evaporated. The test, using water-sensitive papers showed, that the covering rate on the upper surface of leaves was practically 100 %. At the 100 cm and 140 cm level often excess liquid could be observed, and because sticking together of leaves the covering rate on the lower surface can not be estimated, therefore during the next measurements this part were abandoned.

Just before the next measurements of 15th July, excess green parts of plants were removed („green cutting") the sprouts growing too high, too low or growing into the space of the two rows were cut down. Despite of this the foliage had a bigger amount and became more closed, than in the time of previous measurements, its LAI value was 1.898. Nearly 51 % of the sprayed liquid got on the target surface, but also somewhat bigger amount came to the soil surface, 13.46 % and out of the sprayed row it decreased to 7.37 %. Also the deposition at the next rows by the sprayed area increased to 6.84 %. The value of non-controlled loss decreased to 21.39 %.

At the time of the last measurements (13th August) the value of recovery was 56.3 %, which in case of a traditional axial-fan sprayer is a relatively good value. Because of a bigger amount and of closer foliage (LAI = 2.331) the biggest part of the liquid losses got the soil between the rows, amounting to 16.82 %. The rate of non-controlled loss was 10.56 % only. Losses measured on the two neighbouring rows increased to 10.54 %, while below them on the soil 6.02 % of the chemical could be found.

Prior to the beginning of the measurements samples were collected from all the rows and levels to establish the amount of tracing material remaining from the previous treatments. The data evaluations showed, that the remnants from the earlier treatments did not altered the measured values, being its values below 1.0 ng/cm^2, which is two orders lower, than the values measured just following the sprayings.

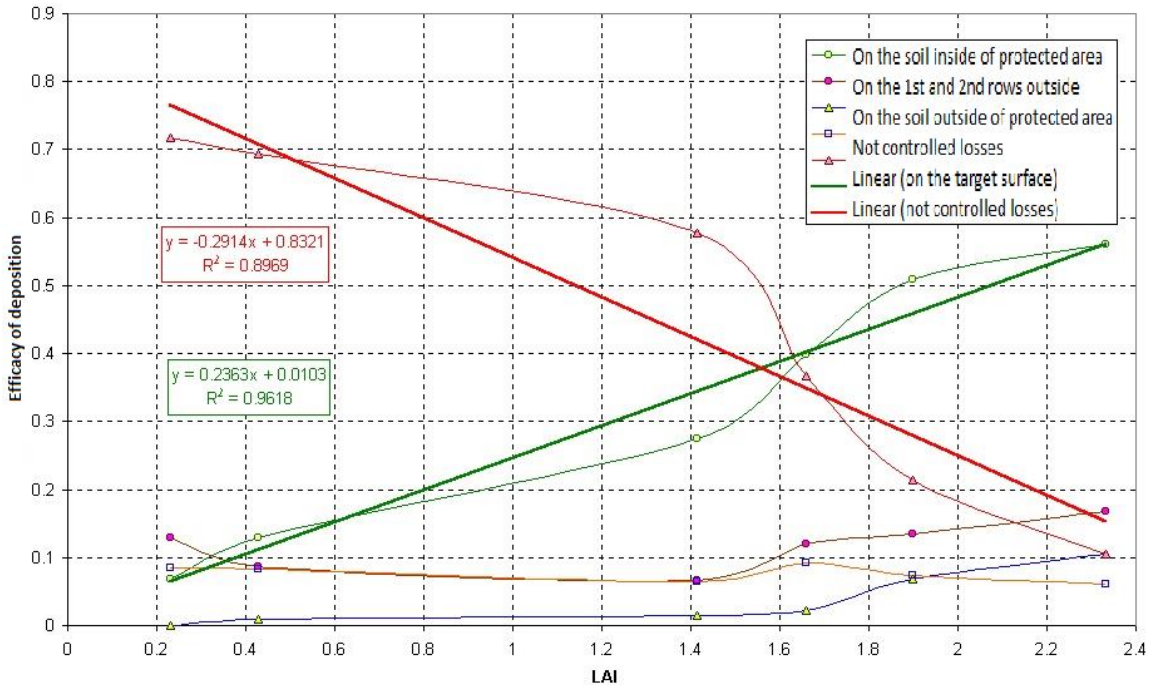

Figure 3. Recovery rates and spraying losses depending from leaf area-index (LAI)

This was influenced also by the weather, since between the measurings at least one rainfall occurred washing down the tracing material, and because there was two weeks between the measures.

From the data it can be concluded, that the increasing LAI had a favourable effect on the deposition values, (including also at the different height levels) but at the same time also the losses increases, since more liquid fall onto the soil (*Figure 3*.). Well observable is the effect of higher liquid amount per hectare.

We could not find a relation between test paper covering rates and measured tracer amounts of the leaf samples taken from the same point. This is because the same amount liquid dispersed into bigger droplets causes lower covering, than dispersed into smaller droplets.

CONCLUSIONS

The evaluation of relations between developmental stage and efficacy of sprayings showed, that the amount of liquid sprayed onto the target surface (that is the foliage) as well as the value of recovery, will mainly be determined by the LAI, which shows the development of the foliage. The efficacy of spraying is very much connected with the value of LAI, their relation is a linear one. The investigations using water-sensitive test papers proved that the increasing LAI causes a change in covering rates of upper and lower leaf surfaces, more liquid will be absorbed on the upper surface and less on the lower surface. It can be stated, that the use of fluorescent marking and of water-sensitive paper tests well complete each other, since using the former one the covering rate can be determined on the upper and lower surface of the leaves, while with the other method the exact amount of recovery can be measured. However the two methods can not be substituted for each other. In case of large sized and dense foliage the application of water-sensitive paper is restricted or even impossible because of the intensive leaf movement, caused by the carry-air. The recovery values of 55-60 % is considered in the literature as a

basis for comparisons, and is in case of traditional axial fan sprayers only acceptable and true, if the foliage is very well developed.
According to the revealing investigations on relations between developmental stage of the orchard plants and of efficacy of spraying, the vine plant in it's initial stage don't has such a large foliage, which would need the work of the fan. At this stage a good covering rate can only be achieved by using the hydraulic pulverization. Because of disconnection of fan the amount of the liquid falling to the soil will be higher, and the covering rate of lower leaf surface will also be lower, which may cause problem at using contact type chemicals. To lower the drift of very small droplets lower pump pressure can be proposed, and bigger nozzle opening at the same liquid dose. The determination of spraying time length using sprayer without carry-air greatly depends on the vine stock variety, on its age, on the producing area, the weather, and also on the sprayer and on its working parameters, therefore to determine of time intervals the actual LAI has to be taken into consideration. Based on the test results of using water-sensitive test papers it is proposed to spray without fan operation up to LAI <0.5. At larger foliage a higher dose may result in a better utilization rate, but it may increase the amount of liquid falling onto the soil. The determination of the moment, when will be necessary to increase the dose of the protecting liquid, depends also on a number of factors, however also in this case the LAI value should be a basis, according to our investigations at LAI of 1.7 – 1.8.

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REFERENCES

FOX, R.D. – BRAZEE, R. D. – REICHARD, D. L. – HALL, F. R. (1990): "Downwind Residue from Air Spraying of a Dwarf Apple Orchard", Transactions of the ASAE, Vol 33(4), 1104-1108. p.
GANZELMEIER, H. (1986):"Abdrift beim Einsatz von Sprüh- und Staubgeräten im Obst- und Ackerbau", Landtechnik, Vol 41(6), 174-179. p.
GÖHLICH, H. – KÜMMEL, K. (1993):"Verteilungsprüfung an Spritz und Sprühgeräten für Raumkulturen", Landtechnik, Vol 48(7), 366-369. p.
HOLOWNICKI, R. – DORUCHOWSKI, G. – GODYN, A. – SWIECHOWSKI, W. (2000): „Variation of SprayDeposit and Loss with Air-Jet Directions applied in Orchards", Journal of Agricultural Engineering Research, Silsoe Research Institute, Vol. 77(2), 129-136. p.
LÁSZLÓ, A. (1999): „Környezetkímélő növényvédelmi eljárások, precíziós kijuttatás, minőség-ellenőrzés", Mezőgazdasági Technika , Vol 40(12), 2-5. p.
MOLTÓ, E. – MARTIN, B. – GUTIÉRREZ, A. (2001): „Pesticide Loss Reduction by Automatic Adaptation of Spraying on Globular Trees", Journal of Agricultural Engineering Research, Silsoe Research Institute, Vol. 77(1), 35-41. p.
SALYANI, M. – HOFFMANN, W. C. (1996):"Air and Spray Distribution from an Air-Carrier Sprayer", Applied Engineering in Agriculture, Vol. 12(5), 539-545. p.