Sprayer calibration training – concept and performance

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Summary
According to the EU directive on sustainable use of pesticides the pesticide users have to be trained on sprayer calibration. A high educative effect of trainings can only be achieved if trainees are motivated and interested in the training, and when the training is performed by the trainer with high competence and practical skills. A concept and programme of calibration training was developed, and then tested by performing the training for trainers. The event was organised in the Research Institute of Horticulture, Skierniewice, Poland, within the Safe Use Initiative (ECPA project). The 10-hour training programme was composed so that the ratio of theory to practice was 40%/60%. The practical part was organized in a way to fully involve the trainees in calibration activities and by that let them gain skills and better understand the procedure. The programme included practical calibration of orchard sprayers by trainees divided into four 5-person teams, followed by verification of the calibration effects during field experiment using water sensitive paper, analyzing he results, and making reports in form of PPT presentations. The elements of competition between the groups made the trainees active, creative and fully involved. The training was found to be instructive and enjoyable.

Introduction
Calibration of sprayer is a crucial action, complementing inspection activity, to make the sprayer apply pesticides accurately and safely. In fact it should be a routine farmer's obligation because the pesticides are too expensive and the environment is too fragile to mandate spray application to non-calibrated sprayer. The experience shows that from the technical point of view the successful pesticide application is a result of using the inspected and calibrated sprayer by the aware and well trained operator.
As required in the directive on sustainable use of pesticides (EC 2009/128) the professional users of pesticides in the EU Member States will have to conduct regular calibrations of application equipment in accordance with obligatory training. Such trainings should ensure that the pesticide users acquire sufficient knowledge on various plant protection issues including sprayer calibration. This may only be achieved if the trainees are motivated and interested in the training, and when the training is performed by the trainer with high competence and practical skills.
The objective of activities described in this paper was to elaborate the concept and perform the calibration training for the trainers (advisors and extension officers), aiming at a high educative effect. The activities were carried out in May 2011, in the Research Institute of Horticulture - Department of Agroengineering, Skierniewice, Poland. The event was organised within the Safe Use Initiative (ECPA project -) in cooperation with Polish Crop Protection Association. The video record of the training course (5-minute video clip: "Facing the real thing - trainers stepping into farmers' shoes") is available on: http://www.youtube.com/watch?v=h3A60xuxqgc

Concept and performance
In order to guarantee a good trainees' perception and gaining practical skills two general assumptions were made: (i) predominance of practical exercises over the theory; (ii) maximal involvement of trainees in the training. The 10-hour training programme was composed so that the ratio of theory to practice was 40%/60%.
The theoretical part started in the afternoon of the first day of training. It was performed in form of PPT presentations (2,5 hours) delivering essential knowledge and meaningful data, supported by a rich illustrative material. The trainees were given the handouts of presentations. The presentations included the following topics:

- Nozzles
  - types - characteristics
  - droplet size – performance and driftability
  - selection and use
- Application parameters
  - targets – spray volume
  - application techniques
  - air flow volume and direction
  - driving velocity
  - nozzle flow rate and pressure
- Procedure
  - assumpions
  - calculations
- Personal safety measures

In order to animate the trainees the presentations were followed by case task exercises and discussion (1,5 hours) which consisted in stating problems and finding solutions. At this stage the trainees were divided into four 5-person teams. Each team was given a separate task to solve based on data and assumptions as shown in Fig. 1, so the trainees could exercise associating facts and making calculations to find out the application parameters best adapted to given situation. The teams were given calibration instructions, nozzle catalogs and calculators, and their task was to complete the table shown in Fig. 1, i.e. to calculate spray volume for given orchards based on tree row volume concept (TRV), calculate driving velocities for given results of driving tests, calculate the required nozzle flow rate, and determine the pressure for given nozzles.

When the trainees were solving specific tasks they recognized the effects of application parameters and understood relationships between them, and they gained skills in calculation the mathematical formulas used in the calibration process. The first day of training was finished with a discussion on the presented topics and results of the case task exercise, and with the instruction on the practical part of the training to be performed in the morning of the next day.

The practical part of the training was organized in a way to involve the trainees in action and keep them all busy. The trainees were working in teams as formed the day before. The task of each team was to perform a full calibration procedure in real situation, check the effects of calibration by designing and performing simple experiment with water sensitive paper (WSP), evaluate obtained results, and report the calibration outcome in form of PPT presentation. The work of teams was observed and evaluated by trainers according to a predefined protocol. The competition between teams and self-evaluation of the effects of their work made the trainees fully committed in what they were doing. Their involvement and commitment was the way to raise interest in the work being performed, fill responsibility for decisions made, and get understanding of the calibration procedure, as well as learn about importance and relationship between application parameters.

TEAM A	TEAM B	TEAM C	TEAM D
Trees H: 3,2 m W: 1,7 m R: 4,0 m	Trees H: 2,2 m W: 1,1 m R: 3,5 m	Trees H: 2,7 m W: 1,4 m R: 4,0 m	Trees H: 3,5 m W: 2,2 m R: 4,0 m
Nozzles 18 pcs TR 80-02 ID 90-015	Nozzles 10 pcs TR 80-015 ID 90-01	Nozzles 10 pcs TR 80-02 ID 90-025	Nozzles 16 pcs TR 80-02 ID 90-03
Driving test - 100 m 58 s	Driving test - 50 m 26 s	Driving test - 100 m 50 s	Driving test - 50 m 30 s
Spray volume ..... l/ha	Spray volume ..... l/ha	Spray volume ..... l/ha	Spray volume ..... l/ha
Driving velocity ..... km/h	Driving velocity ..... km/h	Driving velocity ..... km/h	Driving velocity ..... km/h
Nozzle flow rate ..... l/min	Nozzle flow rate ..... l/min	Nozzle flow rate ..... l/min	Nozzle flow rate ..... l/min
Pressure TR ..... bar ID ..... bar	Pressure TR ..... bar ID ..... bar	Pressure TR ..... bar ID ..... bar	Pressure TR ..... bar ID ..... bar

Fig. 1. Table used for case task exercise.

The programme of practical exercises included:

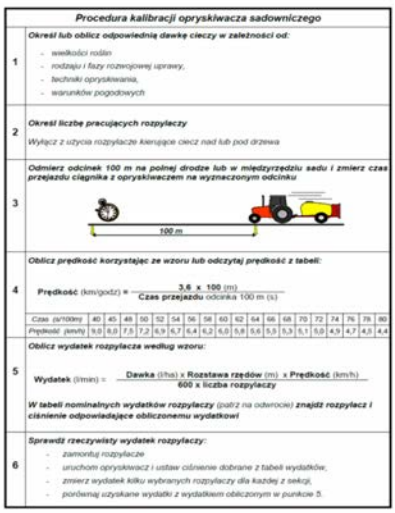
- Practical calibration of orchard sprayer performer in orchard
  - target measurement – spray volume calculation based on TRV concept
  - sprayer-target interaction - airflow adjustment
  - driving test – driving velocity calculation
  - nozzle selection - flow rate calculation
  - pressure setting – flow rate measurement and pressure correction
- Verification of calibration – experiments with WSPs
  - for fine spray nozzles
  - for coarse spray nozzles
- Evaluation of coverage on WSPs
  - visually by trainees
  - image analysis by trainers
- Reports
  - analysis of results
  - elaboration of PPT presentations
- Presenting results
- Trainers' evaluation of team performance
- Discussion
- Certificates of attendance

In order to perform the practical exercise each team of trainees was given a tractor and sprayer, 3 sets of nozzles (different flow-rates and droplet sizes), full set of personal protective equipment for the group members, and a calibration kit including:

- handy calibration instruction (Fig. 2A)
- table to record the calibration results (Fig. 2B)
- nozzle catalogue
- clipboard with notepad and pencil
- calculator
- stopwatch
- measuring tape

- rubber hoses to collect water discharged by nozzles
- graduated beaker
- brush to clean nozzles
- adjustable wrench
- poles to mark driving distance; hummer
- samples of water sensitive paper (WSP)
- bamboo sticks and rubber bands to attach WSP samples
- latex gloves
- coverage scale for visual assessment of spray cover on WSP (Fig. 2C)
- notebook with Excel and Powerpoint

A



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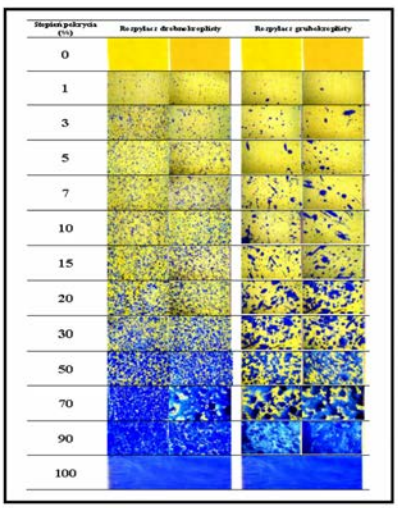

ORCHARD			SPRAY VOLUME	AIR-FLOW			NOZZLES		TRACTOR		DRIVING TEST		DRIVING VELOCITY	FLOW RATE	PRESSURE
Tree HEIGHT m	Tree WIDTH m	ROW SPACING m	l/ha	Gear/ Angle	VOL. m³/h	Range / Direction	No. pcs	Size	Gear	RPM	Distance m	Time s	km/h	l/min	bar

C

Fig. 2. Elements of calibration kit: A – handy calibration instruction; B – table to record calibration results; C – coverage scale for visual assessment of spray cover on WSP samples.

The teams were given tasks to calibrate their sprayers for specific orchards, for applications in normal and windy conditions. Each team worked in different plot of orchard with different sprayer:

- team A: super spindle orchard – directed air-jet sprayer with multi-spout air discharge system
- team B: slender spindle orchard – axial fan sprayer with a radial air discharge system
- team C: hedge-row orchard – double fan sprayer with a cross-flow air discharge system
- team D: traditional orchard – deflector sprayer with a cross-flow air discharge system

The calibration was performed according to the procedure described by Doruchowski et al. (2012). The effect of calibration was verified by carrying out experiment with WSP samples located in the tree canopies to check the spray coverage obtained at the application parameters as determined by the teams for given orchard and sprayer. The experiments were made both for fine- and coarse-spray nozzles to simulate normal and windy conditions. The average wind velocity at the day of practical training was 2,5 m/s.

The time spent for the exercise in orchard was 3 hours. The next 2 hours was used for indoors activities: visual assessment and analysis of spray cover on WSP using coverage scale and Excel sheet, and pre-

paring reports in form of PPT presentation. Once the trainees were busy with making reports the trainers evaluated the WSP samples with computer image analysis. The results of visual assessment made by the trainees were plotted against the respective results of WSP coverage obtained with vision system, and correlations were determined between those two methods of data analysis (Fig. 3).

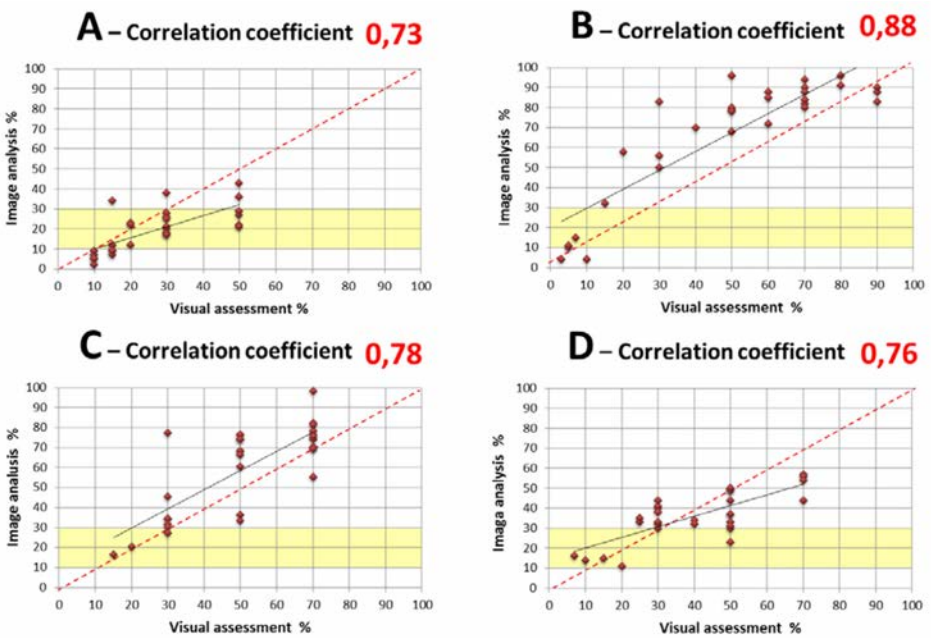

Fig. 3. Correlations between visual assessment and image analysis measurements of coverage on WSP samples obtained by teams A, B, C and D during the field experiment verifying the calibration effects. Preferable coverage range is between 10 and 30%.

The results were presented to the trainees to discuss both the quality of calibration performed by the teams and the reliability of their coverage assessment. It was concluded that the teams A and D obtained the coverage in the trees which was the closest to the preferable range of 10-30%, while the teams B and C produced considerably higher coverage, being possibly the result of the overestimated spray volume. However in team A a few samples were covered less than 10% which may be not enough to guarantee a satisfactory efficacy of treatments. Furthermore the results showed that the visual assessment of coverage was quite reliable in case of all teams (correlations coefficients between 0,73 and 0,88). This evidence was used to convince the trainees that a simple visual assessment of coverage, as a verification of their work, can be trusted and hence may be used during the trainings they conduct for pesticide users.

The last hour of the training was spend for the team reports given by team leaders as PPT presentations, evaluation of the teams' work presented by trainers, discussion and handing out the certificates of attendance.

The training was very well received by the trainees. According to their testimonials it was instructive and enjoyable. The elements of competition between the groups made the trainees active, creative and fully involved. Thus, incorporating the gamification methods in the education process stimulated the trainees' thinking and action, enhanced their perception of the topic and skill gaining, and finally it made the proper calibration process to be imprinted on their minds.

References

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