Determination of the influence of the driving speed on the application parameters of orchard sprayers

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Abstract

Orchard sprayers with air transported fine droplets need an exact adjustment of the air-flow and the spray nozzles in order to reduce the drift of pesticides. The adjustment is made on one hand side by the manufacturer and on the other hand side by the farmer in the orchard by choosing the tractor speed, the PTO shaft rotation speed and the pump pressure. For testing two test beds have been in charge in the region of Styria since almost 2 decades. One of them is able to measure the flow field in a vertical plane representing the tree row in a distance of approx. 1.5 m from the middle of the track. The second measures the water distribution in the same vertical plane. Both are stationary so that the influence of the driving speed can hardly be assessed. High driving speeds up to 12 km/h and the increasing height of the orchards impose additional uncertainties. This was the reason for the present research project, which was intended to investigate the influence of the driving speed. A new air flow measurement test bed has been build, which is able to measure the flow field also during tractor movement in the described vertical plane up to 5 m above ground. Four different sprayers have been investigated in an orchard with and without leaves by visual method for four different speeds to determine the optimal application parameters. The same sprayers have been tested with the moveable flow field test bed. Results show a reasonable correlation between the measurements for all investigated speeds. The differences between the sprayers are evident, nevertheless a method has been found to deduce the correlation between the stationary measurement and the optimal parameters for the orchard. So the stationary flow test bed can be directly used to develop sprayers.

Introduction

What you still can find up to now!

Fig. 1. Current pesticide application using orchard sprayers (to be improved!).

Solution: Resources-saving plant protection in wine crowing and fruit-production

Goals:

- sufficient plant protection substance on the leaves at the perfect time
- low costs (sprayer, tractor, fuel, maintenance, automation, low number of spraying processes, etc.)
- environmental acceptance: small driftage (to air and soil) low noise

environmental-friendly substances

small soil-compaction, -degradation

Needs:

- optimized spraying process
- fine droplets
- small amount of water
- well adjusted air flow (depending on distance between the lines of trees, height, tractor-speed, leafage)
- well adjusted nozzles (depending on substance mass per ha, tractor speed)
- acceptable meteorology
- small tractor-sprayer-tank weight
- correct choice and documentation of spraying processes (substances)

Suggested procedure:

- Data base supported selection and documentation of substances
- Usage of well-tested sprayers (airflow and droplet distribution)
- Sprayer adjustment for PTO shaft rotation speed, tractor speed, pump pressure, and the number and position of open nozzles for every spraying process!

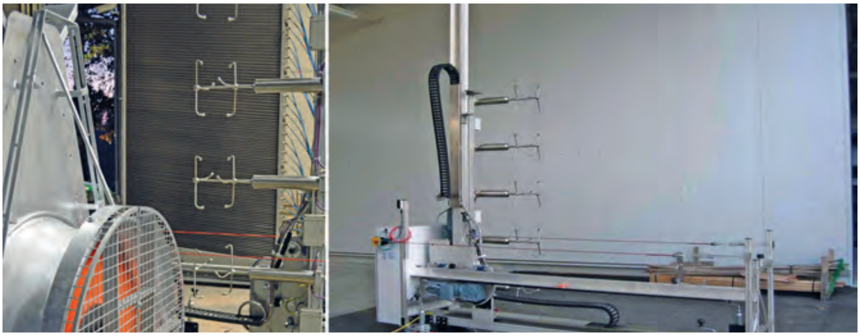
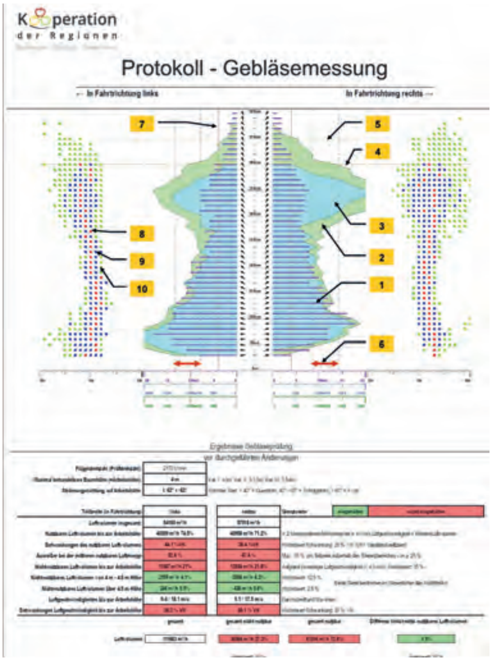


Fig. 2. Air flow test bed for orchard sprayers (equipped with 5 ultrasonic anemometers).

How to test orchard sprayers and how to find the best adjustment

Orchard sprayers with air transported fine droplets need an exact adjustment of the airflow and the spray nozzles in order to reduce the drift of pesticides. The adjustment is made on one hand side by the manufacturer and on the other hand side by the farmer in the orchard by choosing the tractor speed, the PTO shaft rotation speed and the pump pressure. In order to inform farmers about the status of their sprayer's two test beds have been in charge in the region of Styria since almost 2 decades. One of them is able to measure the flow field in a vertical plane representing the tree row in a distance of approx. 1.5 m from the middle of the track. The second test bed measures the water distribution in the same vertical plane. Both test beds are stationary so that the influence of the driving speed can hardly be assessed.



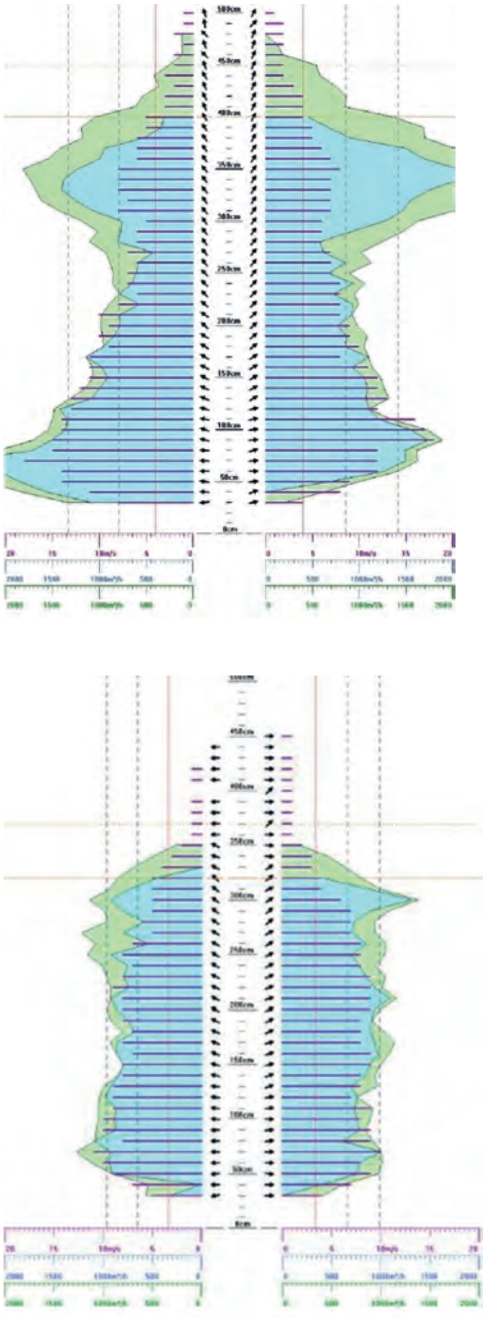


Fig. 3. Measurement protocols for the assessment of the air flow of sprayers.

The results of the air flow measurement are processed and presented in a protocol as can be seen in the following Fig. 3. The protocol shows air speed, direction, symmetry, total volume flow left and right side, etc. There are rigid rules to score the sprayers. Red boxes show a negative assessment. On the right hand side of Fig. 3 two results of the same sprayer without (above) and with (below) optimized air flow are shown.

Influence of the driving speed

Especially the high driving speeds up to 12 km/h and the increasing height of the orchards (up to 5 m) impose additional uncertainties. This was the reason for the present research project, which was intended to investigate the influence of the driving speed. A new air flow measurement test bed has been build, which is able to measure the flow field stationary but also during tractor movement in the described vertical plane in a distance of 1,5 m of the sprayer middle axis up to 5 m above ground. The following two pictures show the experiments, which have been carried out indoor in a hall. Four different sprayers have been investigated for the following three tractor speeds: 6, 9 and 12 km/h. The rotational speed for the sprayers have been found from visual investigations in the orchards.

Fig. 4. Test configuration for the air flow measurement with moving tractor.

In addition all four different sprayers have been investigated in different orchards with and without leaves applying a visual method for four different speeds to determine the optimal

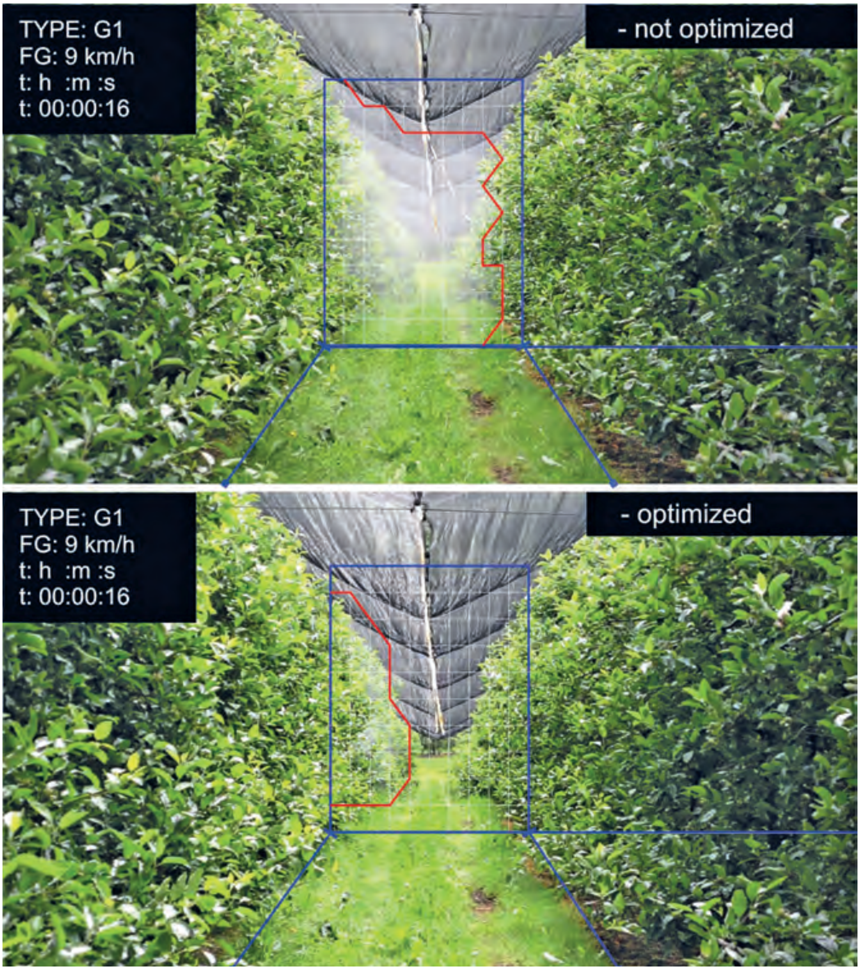


Fig. 5. Visual test of the sprayers in the orchard.

parameters for the pesticide application. The following pictures shows the droplet spray in the neighbouring driving lane. It shows that the driftage and a wrong adjustment of the sprayer can be easily detected in a backlight situation. Here it is to mention, that the sprayers are equipped with ant-driftage nozzles in the upper part of the air outlets.

The next diagram (fig. 6) shows the comparison of the results from the air flow test bed for stationary and in motion cases for all four investigated sprayers. The tests have been carried out for the optimum rotational speeds (U/min) for the individual sprayers.

It shows that an increase in tractor speed requires for the same penetration an increase in the rotational speed of the sprayer. Despite various equipment types, the differences between the devices are in practice negligible. The tests have been carried out for different foliage with a negligible influence on the spray distribution.

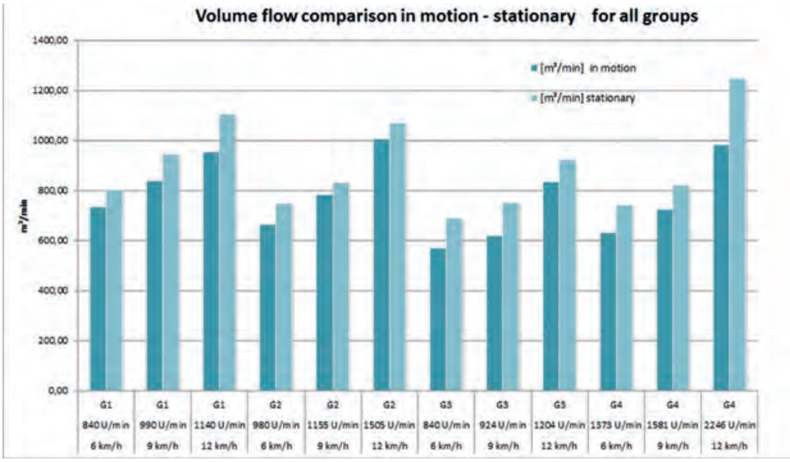


Fig. 6. Volume flow comparison in motion - stationary mean values.

The overall sprayers averaged air volume flow [m^3/min] runs mainly parallel between stationary measurements and measurements in motion. However, the shown curves include all the air speed values above 0 m/s. So they include also the rather turbulent flow between 0 to 1.5 m/s. If the turbulent portion is not taken into account, it results in a difference of air flow rates of around 8%.

Similar investigations have been carried out for smaller and larger row widths (2.8 m, 3.2m). The influences of the driving speed are reduced (2.8 m) or increased (3.2 m) as expected.

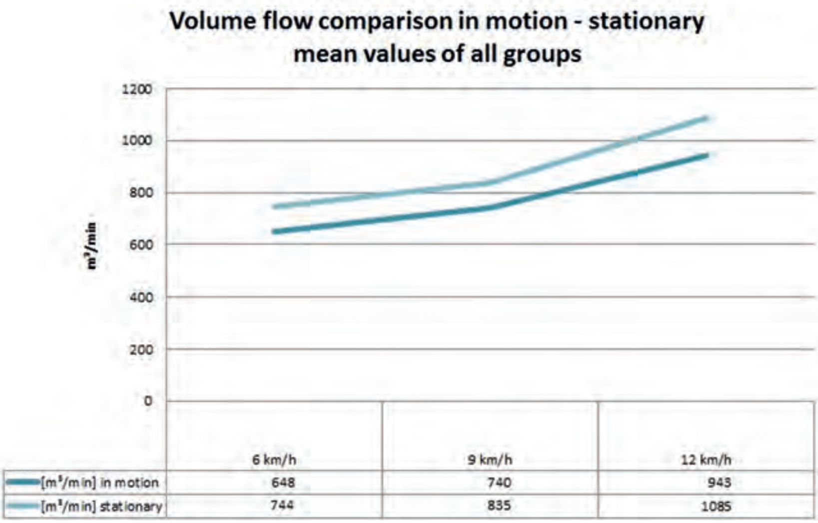


Fig. 7. Volume flow comparison driving-stationary - mean values of all groups.

Interpretation, discussion, and implementation

Stationary measurements of air flow rates on the test bed (fig. 2) are the most important basis of the research project. The results provide a profound picture of the air flow pattern in the vertical plane of the trees. The air flow test bed is already available in the following three regions: Styria (A), South Tyrol (I), and Southern Germany (Lake Constance). The main results of the measurement of a sprayer are summarized and shown in the protocol. The protocol and the whole method has been developed in co-operation of all three regions. This includes the criteria for inclusion in a so-called "positive list" where useful sprayers are recommended. This is done with the knowledge and in collaboration with the major manufacturers. In addition the test beds are compared in a round robin test and give reliable results.

Nevertheless the air flow test beds can only measure stationary and without droplets. This was the reason to set up a research project to investigate the influence of the tractor driving speed and the droplet-transport. The results show a stable correlation between stationary and in motion results for reasonable working conditions. These reasonable working conditions have been checked with visual tests in the orchards for four sprayers and three tractor speeds.

Another part of the effort in the research project has been put into the practical implementation of the results. For this purpose, the relationship between tractor speed, rotational speed of the sprayer (PTO speed), row width, row height, and sprayer type for each of the orchards is implemented in the application software "XComply". This information is now directly accessible for the farmer via smartphone or tablet. He receives the information about the allowed substances and the PTO speed of the selected blower for the requested tractor speed at the beginning of the application. The substances are documented and can easily be reported to the authorities

One major side-effect is the reduced noise as the PTO speed is generally rather low. Examples are given in measurement campaigns of the Bundesanstalt für Landtechnik Wieselburg, Austria, where the air flow of several sprayers have been improved to fulfil the above shown criteria (symmetry., speed, rectangular distribution over the height, etc.). There it was able to reduce the PTO-speed by up to 30% resulting in much smaller fuel consumption and noise emission.

No contract without positive air protocol

It is absolutely necessary to do something against the waste of pesticides and fuel. Therefore it should only be possible to use well suited environmental-friendly plant protection.

The steady-state measurement on the air test bed providing the measurement protocols are suitable for a decision support during equipment purchase. The claim must be raised that every sprayer has to comply with the above mentioned criteria - ie no contract without a positive air protocol!

The air flow criteria compliance of the sprayer is one of the final inspections which has to be done by the manufacturer. The criteria and the corresponding measurement technology are available on the market.

Links

www.sprayertest.org [Portal für die Sprühgerätekontrolle der Kooperation]
www.xcomply.info [homepage of the XComply project]
www.obstwein-technik.eu [Fachgruppe Technik vom Verband der Steirischen Erwerbsobstbauern]