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"Low Loss Crop Protection" A Concept for More Efficient and Safer Spray Application in Tree Fruit

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Summary

To maintain low water volumes with small droplets for professional fruit growing, particle drift deposits had to be reduced to the same amount as with air induction nozzles. By combining fans with cross flow characteristics equipped with a mixed set of small droplet hollow cone nozzles and 2 x 2 air induction nozzles at the top most nozzle positions and an adaptation of the horizontal reach of the air stream to the canopy at any forward speed, a reduction of particle drift deposits of approx. 84% and of 94% under hail netting, has been obtained. The adaptation of fan speed to the canopy also remarkably increased the efficiency of spray deposition on the target and as a side effect resulted in an enormous reduction of fuel consumption and noise emission. To enable the growers to make use of this method called "Low Loss Spray Application" an internet based field book, containing a model for canopy adapted dosing and application has been developed.

Poor vertical air distribution of most orchard sprayers threatened the introduction of this technique and initiated a cooperation of Austrian, Italian and German advisory services in order to test and improve the air distribution of vine and orchard sprayers. Air distribution is measured and adjusted using test stands with ultrasonic sensors and an automated evaluation of the air distribution. The concept is completed by training of the growers and the staff doing the measurements and an annual meeting with the sprayer manufacturers participating in the concept.

Keywords: Canopy adapted spray application, drift reduction, spray cover, fan speed, air distribution, top fruit.

Introduction

In some large fruit growing areas in Europe (Austria, The Netherlands, United Kingdom, Germany) low volume spray application with small droplet nozzles has become standard in the early 1990ies. Reasons for this technique to rapidly spread amongst professional fruit growers have been the high work rate, enabling the use of limited time windows with suitable climatic conditions (e.g. periods with low wind shortly before rain events) for spray application on a large acreage, a good coverage with no visible deposits and no run off, a low risk for phytotoxicity, the possibility to reduce pesticide dose rates, less chances per spray round for the contamination of the operator with concentrated pesticides during preparation of the spray liquid, and also lower costs.

This technique has increasingly been threatened as particle drift deposit became an important issue during the 1990ies and high volume spray application with large droplets from air induction nozzles has officially been introduced as the exclusive way to reduce spray drift after tunnel sprayers failed in top fruit because of practical reasons. Based on the spray drift reduction obtained by air induction nozzles, which is increased by deflector plates to shut off or redirect the air stream on the down wind facing fan side, buffer zones to water courses can officially be reduced by the operator. This technique, resulting in water volumes of approximately 500 – 600 l ha^{-1} created a significant advantage for growers using higher water volumes before but would have created severe problems for growers using low volume spraying techniques of less than approx. 250 l ha^{-1} for many years.

Reducing Particle Drift Deposits of Small Droplet Nozzles

To maintain this highly efficient spray application technique for tree fruit and wine growers, an alternative method of spray drift reduction resulting at least in a 75% reduction according the German drift reduction classification has been developed. This method combines fans with cross flow characteristics, a mixed set of nozzles with four low flow rate air induction nozzles ("Albuz AVI 8001" or "Lechler IDK 9001") at the two top most nozzle positions of the fan and hollow cone nozzles ("Albuz ATR purple") at any other positions. For spray application at any forward speed, fan speed is adapted to the canopy so that the spray mist does only slightly exit the tree at its broadest position into the next alley way. Adapting fan speed to the canopy at forward speeds of 6, 9 and 12 km h^{-1} obtained an average spray drift reduction of 84%, allowing a registration in the official German 75% drift reduction class (figure 1). Repeating the trials with the same settings under hail netting increased the spray drift reduction by approximately 12%, leading to an average spray drift reduction of about 94%, thus allowing a classification in the 90% spray drift reduction class.

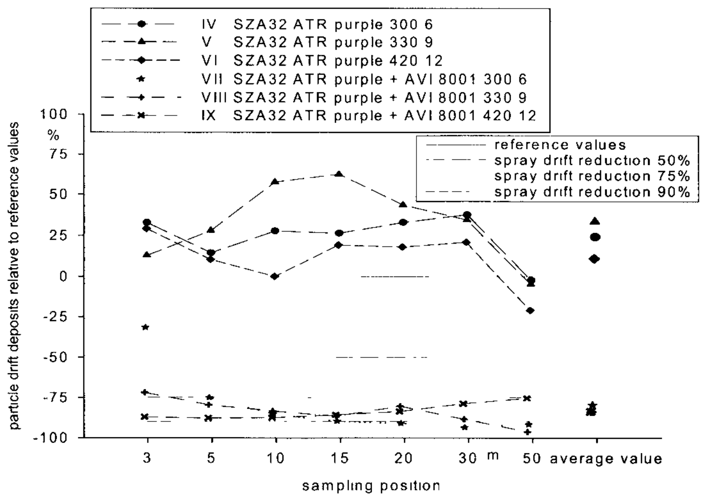

Figure 1: Relative changes in particle drift deposits of an axial fan with cross flow characteristics at various forward speeds and canopy adapted fan speed with a full set of 16 hollow cone nozzles (upper full lines) and a mixed set of 4 air induction nozzles and 10 hollow cone nozzles (lower dotted lines).

The results clearly proved that an almost horizontal air stream adapted to canopy width at any forward speed, in combination with a mixed set of hollow cone / air induction nozzles without any constructive modification of the fan leads to a spray drift reduction equivalent to that of orchard sprayers equipped with a full set of air induction nozzles. Since the method may easily be used with orchard sprayers with cross flow characteristics already in use on the farms, the technology may much more rapidly be implemented in practise compared to methods that require purchasing new orchard sprayers. Thus the method developed is a chance to combine the enormous advantages of small droplets and low water volumes for the growers with the demands of authorities and the public for a significant reduction of spray drift. It is also an answer to the growers needs, since for many growers relying on low water volumes it prevents the serious problems arising from a change towards classical spray drift reduction with a full set of air induction nozzles and high water volumes. The method therefore has to be taken into consideration by future regulations concerning spray drift reduction in tree crops and grape vines.

The Effect of Canopy Adapted Fan Speed on Spray Deposition

To assess the influence of a canopy adapted fan speed on spray deposition, trials have been carried out with an axial fan with cross flow characteristics and a full set of hollow cone nozzles (Albuz ATR purple). The sprayer has been operated in three different canopy systems (three row bed, slender spindle and super spindle) after the MABO-dosing model. This model calculates pesticide dose rate, water volume and forward speed from net acreage, row distance, canopy width and the number of open nozzles via reference values of the net spraying time of a reference orchard. Spray liquid pressure is kept constant to guarantee the desired droplet spectrum in all orchards and to reduce the number of variables to be controlled by the operator. The horizontal reach of the air stream at each forward speed has been adapted to the canopy by fan speed, so that only very little spray mist left the canopy into the next alley way. The trial revealed a considerable increase of the efficiency of spray deposition on the target; especially on the upper leaf surface. It also revealed a reduction of the excessive deposition on the lower leaf surface. Changes in the efficiency of spray deposit parameters compared to classical spray application with high fan speed and relatively low forward speed, calculated per liter of liquid sprayed, are shown in table 1:

Changes in efficiency	3-row Bed	Slender Spindle	Super Spindle
Spray deposit (entire leaf) µg cm^{-2} per liter of liquid sprayed	**+14%**	**+29%**	**+35%**
Relative Spray Cover **(upper leaf surface)** % coverage per liter of liquid sprayed	**-29%**	**+26%**	**+67%**
(lower leaf surface)	-27%	-3%	+7%
Droplet Deposit Density **(upper leaf surface)** number of droplets cm^{-2} per liter of liquid sprayed	**-5%**	**+27%**	**+55%**
(lower leaf surface)	+17%	+28%	+27%

Table 1: Changes of parameters of the spray cover of an axial fan with cross flow characteristics comparing operation with canopy adapted fan speed and forward speed to full fan speed and relatively low forward speed.

As side effects the adaptation of fan speed to the target also reduces fuel consumption and noise emissions by up to approximately 80%; cutting fuel costs and preventing complaints from urban settlements in close vicinity of the orchards.

Poor Air Distribution of Sprayer Fans: The Unexpected Obstacle

Unfortunately the vast majority of fan types with cross flow characteristics showed a very uneven vertical air distribution (figure 2) and thus have been unusable for this method which requires a uniform horizontal reach of the air stream over the working height. As this appeared to be a wide spread and severe problem

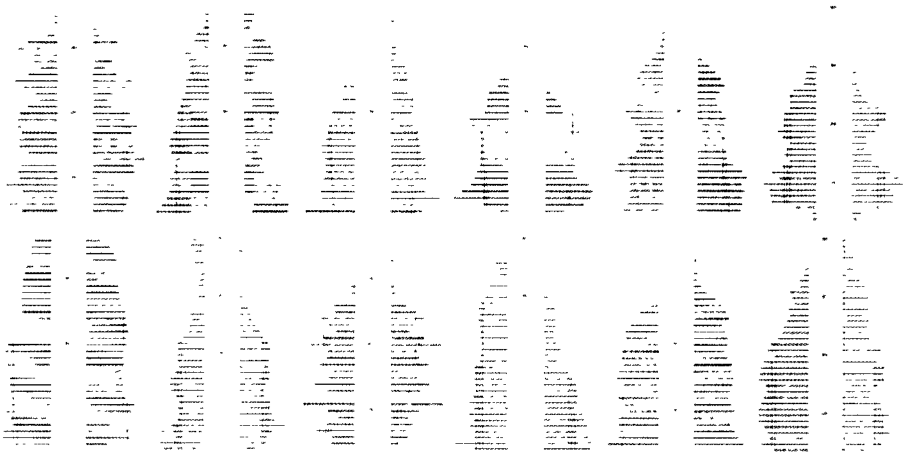

Figure 2: Air distribution (maximum air speed and air stream direction) of various fans from orchards sprayers with cross flow characteristics.

threatening the introduction of “Low Loss Spray Application”, a joint venture of advisory services in Austria (“Verband der steirischen Erwerbsobstbauern”), Italy (“Südtiroler Beratungsring für Obst- und Weinbau”) and Germany (“Marktgemeinschaft Bodenseeobst eG”) covering a production area of approximately 30.000 ha, for testing, adjusting and improving the air distribution of orchard sprayers with an air distribution test stand has been founded. The equipment is based on ultrasonic sensors measuring wind speed and direction within a 10 x 10 cm sensing area and a measuring range of 2 x 5 m. The software amongst other parameters calculates the usable air stream of a fan (the air with minimum volume and speed suitable to penetrate the canopy while driving in the orchard) and automatically creates an evaluation of the fan according to a set of predefined parameters (figure 3). Guidelines developed by the cooperation define the requirements for a vertical air distribution suitable for canopy adapted spray application as the basis of “Low Loss Spray Application”. As a result after hundreds of fans tested it may be concluded that a uniform vertical air distribution is severely disturbed by smallest obstacles in the air system of a fan like reduced pipe diameters from a too small bending radius, rough surfaces of air ducts and others and may not at all be properly adjusted without a test stand.

Incorporation of Growers and Sprayer Manufacturers

In order to guide the grower in correctly using “Low Loss Spray Application”, an electronic field book complying with the current systems for quality assurance has been developed, which amongst other dosing models contains the MABO model for canopy related dosing and spray application. With this internet based software growers compose a “recipe” which contains the blocks that are to be sprayed, the sprayer and the products to be used, with the software calculating water volume, pesticide dose rates and forward speed for each individual block selected. After the spray round has been finished, the software documents the treatment and updates the stock of the products used, calculates earliest potential harvest dates and updates a number of parameters from the registration concerning the use of the pesticides as e.g. phenological periods cleared for its use and the number of sprays per indication and vegetation period, for any individual orchard block.

On annual meetings with manufacturers participating in the concept, results and observations concerning fan

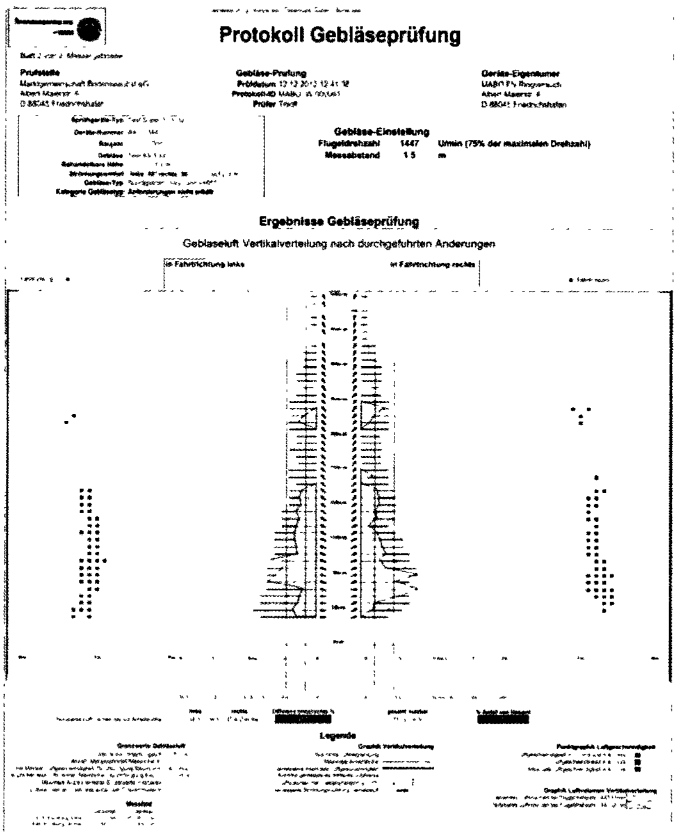

Figure 3: Template of page 2 of the air distribution protocol with maximum wind speed (horizontal lines, wind direction (black arrows), total (light grey area) and usable (grey area) air volume + cross distribution of the air volume (grey dots = unusable, black dots = usable).

performance as well as potential solutions for problems detected, are discussed. The staff is informed and trained before starting sprayer testing and following improvements of the hard- and software and the protocol of the test equipment. Growers are trained in general meetings as well as in special workshops, courses, during the testing of sprayers and before purchasing new sprayers.

With this final component, the concept of "Low Loss Crop Protection" is complete, starting with a suitable air and spray liquid distribution of the sprayer, incorporating a method for spray drift reduction with low water volumes and small droplets, a model for canopy adapted dosing and spray application, a software calculating all parameters required for application method as well as documentation of the treatments, and ending with the education of the growers applying the concept and a continuous dialog with the manufacturers to improve orchard and vineyard spray equipment.

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