Results and Conclusions from Five Years Measuring and Adjusting Air Distribution of Brand New Sprayers for 3D Crops

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Canopy Related Spray Application: Effects of Fan Construction

The air stream is the means for transporting the droplets into the target structure, but must not remove them from there. The fan is not an air force! **All negative effects increase** and **all positive effects decrease** with an increasing vertical angle of the air stream and excessive fan speed!

Quality of spray application is determined by a) **fan type and adjustment to the working height required on the farm**
(task of the manufacturer and the testing institution)
Canopy Related Spray Application: Effects of the Use of the Fan

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b) The setting of fan speed and forward speed (task of the grower and the advisor)
The Air Distribution: The Status Quo and the Goal

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Axial fan at full fan speed

Cross flow fan at canopy adapted fan speed
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How needs the air distribution to look like at the test bench as the prerequisite to keep a maximum of droplets inside the canopy and deposit them at the target structure?

Axial fan

Cross flow fan
The Vertical Air Distribution: The Influence of Fan Speed

Air flow and horizontal reach need to decrease with decreasing fan speed, but working height needs to stay constant!
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Vertical Air Distribution: 9 Fans of the Same Type

Before
Results and Conclusions from Five Years Measuring and Adjusting Air Distribution of Brand New Sprayers for 3D Crops

Vertical Air Distribution: 9 Fans of the Same Type and After
Air Distribution: Experiences From 5 Years of Measurements

- Point source fans without cross flow characteristics are not suitable for canopy adapted spray application

- There are almost no fans that might be safely operated at low fan speed (min. 300 min\(^{-1}\) PTO low fan gear) without a risk for poor pest and disease control

- Air distribution is extremely sensitive to even the smallest obstacle: deflection plates, cross sections, radiuses, angles, edges, safety grids, handmade parts (plastic), thermoplastic materials, surface structures (galvanized/powder coated)

- Inaccuracies during production of components and assembly make any! fan of a series an individuum

- Right now manufacturers don´t know the working height required by the buyer which prevents even pre-adjustment at the manufacturer
Air Distribution: Experiences From 5 Years of Measurements

Aerodynamics of Tower Sprayers

Number, shapes and positioning of deflection plates by the manufacturer

The original construction of the tower is not referring to the physical principle of the fan.
Aerodynamics of Tower Sprayers

Number, shapes and positioning of deflection plates by the manufacturer

Number, shapes and positioning of deflection plates after optimization at an air test bench (2000)

The test bench resulted in completely different numbers, shapes and positions of deflection plates.
Components do not fit together precisely
Air Distribution: Experiences From 5 Years of Measurements

Components do not fit together precisely

Already plain fans (without galvanizing, flaps and deflection plates) from a series
Air Distribution: Experiences From 5 Years of Measurements

Components do not fit together precisely

Components that should be circular, are elliptic: Assembly is accidental and so is the effect
Air Distribution: Experiences From 5 Years of Measurements

Hand made components (circular ring for redirecting air from axial to radial)

Hand made components (glass-fiber reinforced epoxy resin) are too inaccurate!
Air Distribution: Experiences From 5 Years of Measurements

Hand made components (circular ring for redirecting air from axial to radial) are too inaccurate!

Hand made components (glass-fiber reinforced epoxy resin) are too inaccurate!
Spouts made from thermo plastics frequently show deformed openings. Deformed openings (convex ↔ concave) affect air flow and distribution.
Air Distribution: Experiences From 5 Years of Measurements

Short circuits cause uneven air distribution of tangential fans

Too big distances between rotor and housing cause shoulders in the vertical air distribution
Air Distribution: Experiences From 5 Years of Measurements

The only known case where obstacles improve air distribution

Safety rods in tangential fans change a triangular air distribution of the fan units into a rectangular distribution, but at the cost of a ~20% loss of air flow
Air Distribution: Experiences From 5 Years of Measurements

Securing deflection plates and flaps after the adjustment

Positions of deflection plates are extremely sensitive with respect to position and orientation, requiring securing against unintentional adjustments.
Air Distribution: Experiences From 5 Years of Measurements

Missing aerodynamic construction, inaccuracies during production of components and assembly and unsuitable materials are the main causes for the variation of the air distribution within individual fans of a series!

Why did manufacturers not pay much attention to the quality of the air distribution?

♦ Still today it is a widespread opinion, that high air volume at high air speed is required for good spray cover

♦ There was no demand for accuracy because sprayers generally have been operated at excessive fan speed and at low forward speed

♦ In most cases poor vertical air distribution is camouflaged by excessive fan speed and low forward speed
Air Distribution: Conclusions From 5 Years of Measurements

- Improvement of vertical air distribution and accuracy during production of components and assembly
  
a) are the key towards canopy adapted spray application
  
b) reduces time consumption for adjusting air distribution

- Despite all the improvements individual measurement and adjustment of the vertical air distribution of brand new sprayers before purchase remains an absolute need:

- Farm specific tree height requires an individual adjustment of the working height
  
The same amount of air flow needs to be adjusted to farm specific working height and distributed evenly over this working height!

- After the adjustment all deflection plates and flaps need to be permanently secured!

- After adjustment and purchase:

  Keep your hands off from flaps and deflection plates!!!
Canopy Adapted Spray Application: Environmental Potentials

Pesticide Consumption: With hollow cone nozzles, canopy adapted spray application in slim canopies compensates a 35% reduction of pesticide dose rates.

Results from fan type testing (19 different fan types used in fruit production):

**Fan specific**
**Fuel consumption:** The „strongest“ fan consumes 6.5 x more fuel/hour than the „weakest“

**Energy efficiency:** Per m³ of usable air flow, the most inefficient fan consumes 5.3 x more energy than the most efficient one.

**User specific**
**Diesel consumption:** In slim canopy systems (canopy width 1.0 m) the most efficient fan operated at 300 PTO low gear versus the most inefficient fan at 540 PTO high gear:

\[
\frac{0.26}{10.6} \text{ l/h} = 97.5\% \text{ lower Diesel consumption}
\]

**Noise emission:** In slim canopy systems (canopy width 1.0 m) the most silent fan operated at 300 PTO low gear versus the most noisy fan at 540 PTO high gear:

\[
68/94 \text{ dB(A)} = -36 \text{ dB} = 99.75\% \text{ lower noise level}
\]
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Thank You for Your Attention!

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