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Dynamic distribution performance of crop spraying equipment

Because evaluation of dynamic distribution performance of sprayers under field conditions demands a high input of trial technology and results in comparatively low result reproducibility, investigations into spraying equipment performances have not, up until now, been complete. To enable definition of an European standard for spraying equipment the Federal Institute of Biology has sought possibilities of determining distribution performance of spraying equipment under field conditions via simple trial equipment and laboratory tests.

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Keywords

Field sprayers, boom movement, spray deposit distribution

In the distribution of plant protection material onto field crops, sprayer boom movements lead to over or under spray applications on the target areas. Up until now this has not been taken account of in the testing of sprayers where the distribution quality of the equipment is generally checked in channel test stations [1].

In that the testing for spray distribution involves a lot of effort, it is practical to define the boom movements which then allows an evaluation of the implement and a conclusion regarding spray distribution performance in the field.

At the Federal Institute of Biology (BBA) a series of trials were carried out with sprayers of different models and working widths according to current technology standards to investigate the dynamic distribution of material in the direction of travel under working conditions [2, 3].

Testing an additional characteristic of the equipment meant different methods were also applied for comparing the implement dynamics with a group of trailer sprays. This work is briefly described in the following text.

Materials and methods

To investigate the dynamic characteristics of sprayer booms and their attachment, the BBA had the use of a servo-hydraulic oscillation test station in which the sprayers could be moved with six degrees of oscillation possibility. The boom movements thus produced were recorded by an ultra-sonic measuring device. A specially developed device for measuring the spray application enabled an online measurement of the longitudinal distribution of the spray application. The result from 10 cm • 10 cm was then adjusted to the lateral distribution measurement.

Starting point for the evaluation involved driving each sprayer along tramlines. Many test drives in the field were carried out with, in each case, a chosen group of trailed and mounted sprayers. The accelerations on the frames of the sprayers recorded during the field journey were reproduced on the oscillation test station and, totalled in each case with a standard movement for trailed and mounted implements. With the results thus generated the field conditions were able to be reproduced and the vertical and horizontal boom movements, as well as the dynamic application of spray in direction of travel, very precisely recorded.

According to the method developed by Clijmans [4] further tests were carried out in which the implements were shaken with sine oscillations under a wheel in a sequence range of from 0.2 to 3 Hz. A reduction in input signal amplitude of 1/f was chosen in order to avoid damaging the testing or recording equipment during high frequencies.

Moreover, from the results of the movement recording, natural frequencies were determined via Fourier Transformation for the simulated field travel as well as for the sine movements.

Additionally the BBA carried out recoil oscillation trials where the end of the booms were moved 0.5 m in the vertical and horizontal directions and the recoil measured. In this way it is also possible to directly determine from the time-notation in the recording the natural frequencies and their related damping.

Results

The investigations on technology level have shown that, in principle, a more consistent distribution is possible with the trailed implements compared with mounted ones (*fig. 1*).The reason for this could be that the gyrations of the tractor are not directly transferred to the pulled implement. On the other hand, the greater resistance of wider attachments in general means a lower variation coefficient of the spray application distribution (VC) with implements of greater working widths.

Through the different methods investigated, the natural frequencies f_N of the sprayer, as well as resultant amplitudes A_N to the respective input signals were able to be determined. Comparatively presented in *figure 2* as a measurement of the investigated implement's oscillation damping capacity are the first natural frequency and the relative amplitude determined from the oscillation trial.

As has been shown in separate measure-

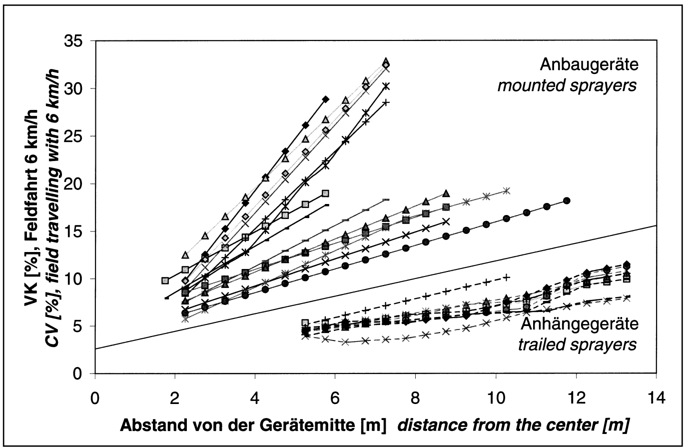

Fig. 1: Dynamic coefficient of variation of different mounted and trailed sprayers in driving direction; on the shaker simulated field travelling with 6 km/h

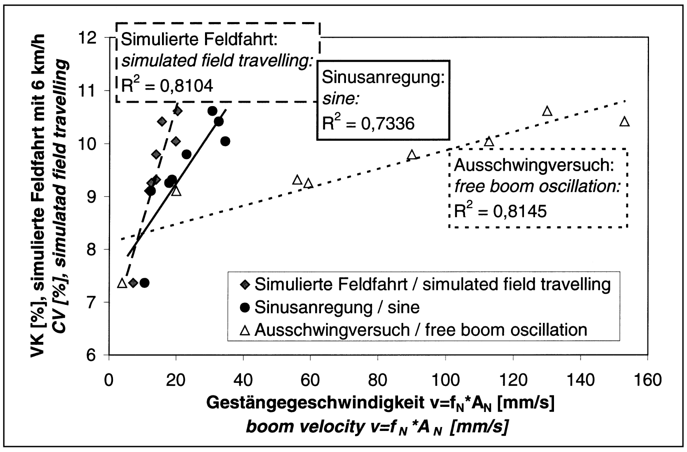

Fig. 3: Correlation of the distribution for the simulated field travelling and the boom movement, defined by the first horizontal natural frequency and the standard deviation of the boom oscillation for the three used methods

ments, with the flat spray nozzles that were used, the VC of the spray application in the vertical direction correlated with the boom movement, and in the horizontal direction with the boom speed. Thus, from a constructional point of view, a long recoil swing in both directions has to be avoided. In the horizontal direction the recoil oscillations in starting condition should take place with as low speed as possible.

In that the horizontal boom movement has an influence on the dynamic spray application [2], the determined characteristic boom speeds were compared with the VC of the spray distribution under field conditions (*fig. 3*). For the simulated field travel and the sine movement, the boom speed was determined as a product of the first natural frequency with the standard deviation of the boom swing. In the boom oscillation trial the amplitude after half an oscillation movement was used instead of the standard deviation of the boom movement.

A linear relationship between the horizontal boom speed dependent on the input signal and the VC of the spray distribution was able to be determined under field conditions.

Conclusion

The general trend towards greater working widths is of advantage from the aspect of dynamic distribution quality under field conditions.

From the point of view of a comparative evaluation of sprayers, the three investigated measuring methods showed that there was a tendency for a linear relationship between the spray distribution under field conditions and the horizontal boom velocity as determined from each method within the tested implement groups. The boom oscillation tests delivered good, differentiated, and clear results with a high degree of reproducability within the comparatively simple trail methodology.

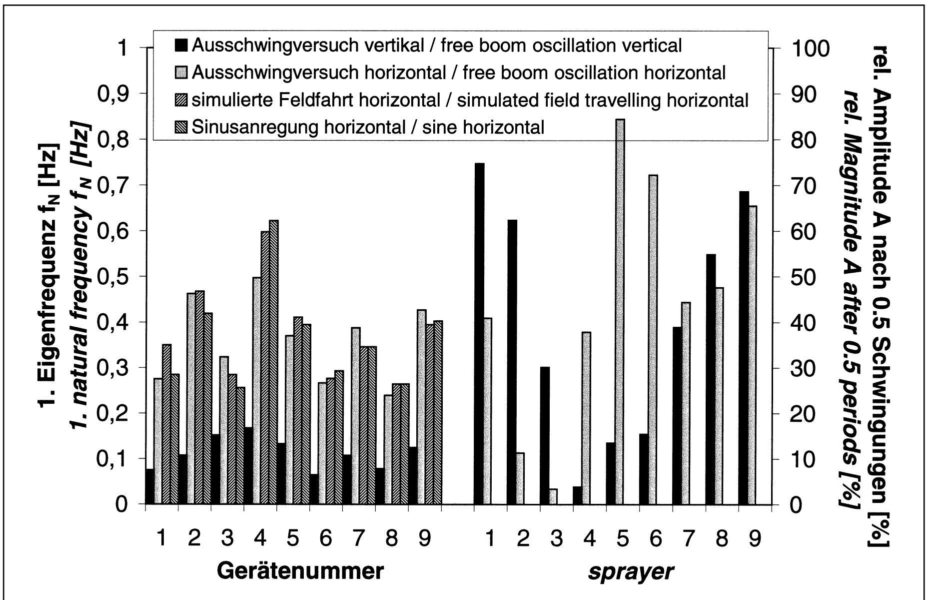

Fig. 2: First horizontal and vertical natural frequencies of the booms as the result of the three tested methods and reduction of the magnitude in-between one period, calculated from the free boom oscillation test

Literature

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