Balancing Drift Management with Biological Performance and Efficacy

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Abstract

Field trials close to farmer's conditions have been conducted over the last 10 years in the most important indications covering arable crops, viniculture and apple production to investigate the influence of coarse-droplet application on the biological effect of crop protection products in Germany. Treatments with different techniques, varieties, amounts of water etc. were set up for the purpose of nozzle comparison to reflect a broad range of application scenarios. Data from 130 biological comparisons in apple production, 100 biological comparison in viniculture and 146 biological comparisons in arable crops from various indications using registered crop protection products with varying mode of action were normalised and assessed for frequency distribution. Looking at the results of most of the indications investigated, there are no significant differences between coarse-droplet application with injector nozzles and fine-droplet application. Coarse-droplet application tended to improve slightly the reliability of efficacy in fungicide indication. Whereas in defined herbicide indications fine droplet applications performed slightly better.

Introduction

Application techniques are generally regarded as a significant factor influencing the biological effect of crop protection products. Nevertheless, only a small number of comparisons under realistic conditions have been performed to investigate the effect of technical parameters. This is partly because application technique trials are complex to organise, but also because it is difficult to devise suitable differentiated trial objectives that are sufficiently relevant to growers. Application techniques generally comprise a number of parameters that affect the way in which the spray liquid, and therefore the active substance, reaches the plant (initial coating on the target surface). This initial coating is affected by the weather conditions (temperature, air humidity, wind speed) as well during application and for a short time afterwards, the equipment used (airflow, equipment setting etc.) and the canopy structure. The amount of the initial coating is also affected by the position of the leaves and more particularly by the nature of their surface. In addition, droplet size is a key factor in determining how the active substance is deposited, while the speed and direction of the spray are also very important. Many experiences and historical statements concluded that fine-droplet applications were better in terms of biological efficacy. The theory behind this was that it achieved a more even coating on the upper and lower sides of the leaf. Fine and medium droplet application therefore had been the standard procedure for many years.

Attention has now turned to drift-reducing applications in view of stricter risk assessments aimed at protecting water sources and non-target organisms from drift of crop protection products. Drift is defined as the proportion of the active substance administered that will not be deposited inside the area being treated. Measures to reduce the drift sediment are mainly of a technical nature. Expensive procedures such as recycling technique have in the past reached the stage at which they could technically be used, but have not proved popular in practice on the reasons of cost and technical complexity.

Coarse-droplet application via injector nozzles appears a promising alternative that might make a significant contribution reducing drift without having extensive technical or financial input.
For many years there has been a noticeable trend towards the use of injector nozzles starting in arable farming followed in high crops like orchards and vine yards, with drift reduction at the forefront of this move. Preliminary and individually published trial results and practical experience have shown that the coarse-droplet application had no any detrimental effects (Frießleben et al. 2000).

Various institutions and companies in Germany have conducted trials to evaluate injector nozzles in the past few years. The fundamental question that all the trial sponsors wanted to answer was: What influence does coarse-droplet application have on the biological effect of a crop protection product compared to the previous standard method? The trials have all been individually assessed, published and used by regional farming extension services (Koch et al. 2001; Frießleben, Oeser 2000; Schmidt et al. 2001).

Equipment and Methods

The author had assessed all available trial results (comparing different nozzle types with regard to efficacy) from the various fruit, vinery and arable growing regions of Germany and summarised these trial results in this paper. Evaluation of a broader set of data drawn from various real application scenarios may highlight trends which cannot be statistically substantiated in a single trial. Like every trial objective, the influence of application techniques is affected by a range of external factors that are hard to quantify in individual cases. The complex nature of application technique trials makes them much more demanding than conventional crop protection efficacy trials. Settings specific to the equipment being used, such as application speed, nozzle discharge etc. have to be carefully calibrated for each study arm so as to exclude in advance technical trial errors.

The principal aim of the investigations was to evaluate the influence of coarse droplet pressure/nozzle combinations compared to the previous standard technique (hollow cone / flat fan fine medium droplet nozzles) on the effect of the crop protection products applying crop protection products in a wide range of application scenarios.

The trials were conducted using state-of-the-art equipment used by growers with the settings recommended for spraying equipment being used to treat fruit crops (Kaul et al. 1998). The range of equipment types, varieties and spray volumes used reflects many realistic application scenarios.

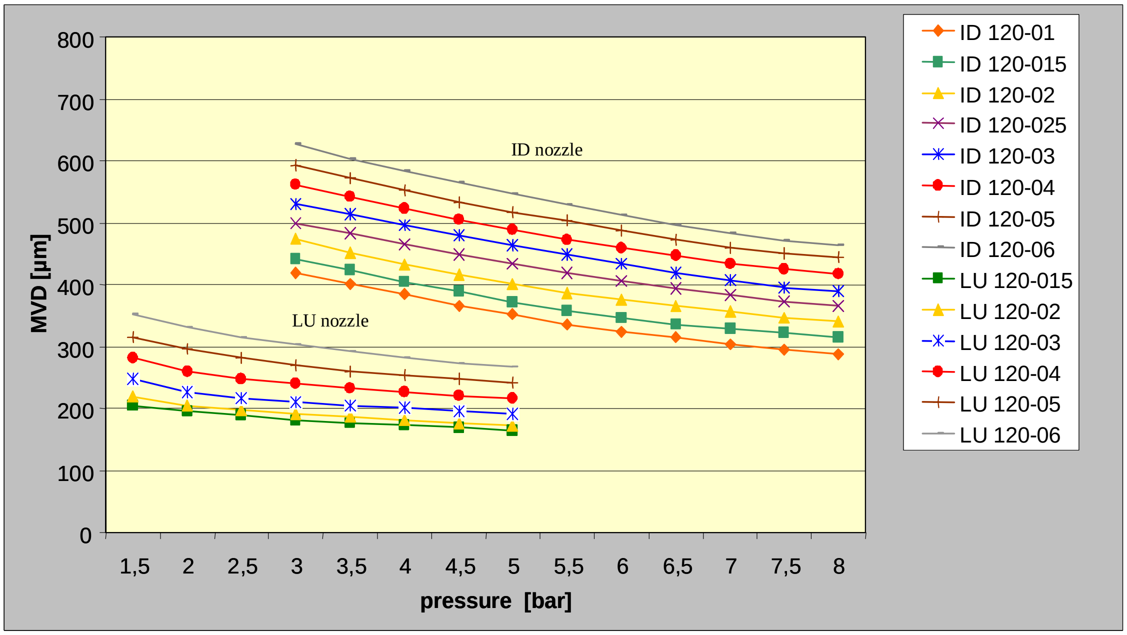
All the trials used registered crop protection products to control the target pests present. Application volumes and dates were selected on the basis of local experience, often tending towards the worst case: lower application volumes, longer intervals between applications and choice of product.

The selection conditions for the nozzle technique being tested were rendered more severe by setting high infestation levels. Experienced trial officer assessed the severity of pathogen infestation in the trials, sometimes on several occasions, in line with generally accepted assessment guidelines. The differences in absolute infestation levels were differentiated in all the trials, and converted to produce a comparative evaluation. This means that the assessed effect of the standard nozzle in an individual trial was recorded as 100 and the effect achieved with the coarse-droplet application was compared to that figure in relative terms. The pairs of variants thus converted were subjected to statistical evaluation on the basis of frequency distributions. The data available allows making substantiated statements regarding relevant questions. For some indications only a small number of trials had been conducted, and in those cases conclusions will be limited.

Results

The comparison of the tested nozzle types (fig. 1) demonstrates the significant difference in droplet sizes between the standard and injector nozzle (Heinkel, 2004)

Summarizing the trial results conducted in orchards no significant difference could be observed. A comparison of the average values (fig. 2) of the individual indications and water application volumes tested produced the following overall results:



* MVD = Medium volumetric droplet size in µ

Figure 1: MVD comparison of different nozzle types manufactured by LECHLER GmbH & Co KG

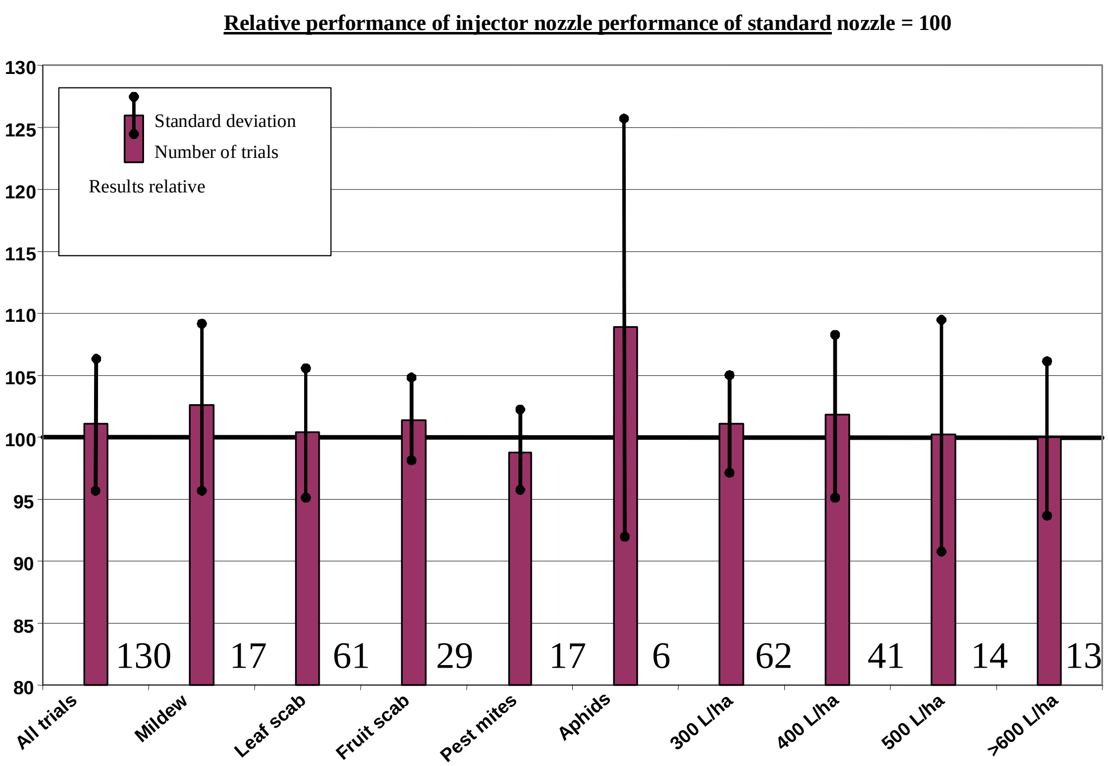


Figure 2: Mean values and standard deviations for nozzle comparisons for various indications in apple production and different spray volumes (L/ha total)

- Taking the average of all the indication specific results no significant difference in effect was found for any of the indications examined in the trials (powdery mildew; leaf scab; fruit scab; pest mites).
- Taking the average of six tests conducted on aphid control the performance of injector nozzles was found to be equivalent to that of the previous standard technique, though individual results varied markedly.
- Individual comparisons between the nozzle types tested showed no differences in biological efficacy when the volume of spray solution applied was between 300 and > 600 l/ha, which is equivalent to a water application volume of 150 to > 300 l/ha/per m crown height.
- The objective of the trial and the evaluation method used do not allow us to make any statements regarding the influence of spray solution volumes on the reliability of efficacy of the crop protection products used in the tests.

Figure 3 illustrates the summary of the frequency distribution of relative nozzle comparisons in apple production. At least 2/3rd of the trial results of the injector nozzles were identical or even better than the fine droplet standard in apple production.

When the absolute efficacy rates achieved by the standard nozzles had been compared with the relative effects of the injector nozzles in each case, the relatively greatest fluctuations, both positive and negative, could be found in the < 80% absolute efficacy range. Fluctuations in test results are much smaller in the > 90% absolute efficacy range, i.e. neither negative nor positive deviations were observed at high efficacy rates (fig. 4).

Frequency distribution of trial results in arable crops followed the same trend (fig. 5). Selecting the fungicide trial results a higher portion of the trials tends to had better efficacy using coarse droplet injector nozzles (fig. 6). At least 75% of the trial results of the injector nozzles were identical or even better than the fine droplet standard in arable crops applying fungicides.
Comparable trial results could be assessed in 100 trial results in vinery production (fig.7 & 8) (Frießleben et.al 2004)

Discussion of Results

Application techniques have an impact on the efficacy of crop protection products used. Nozzle technology has become a matter of great interest in this context over the past few years. Technological advances made mainly in response to the issue of drift have led to a fundamental shift in thinking.

The outcome of this evaluation is that drift-reducing technology, and in particular coarse droplet applications, do not have any detrimental impact on efficacy in many indications in arable crops, viniculture and apple production at different application scenarios. This equivalence in efficacy is a positive finding, as it means that the well-established advantages of coarse-droplet applications are accessible since biological efficacy is retained. Though we were unable to discuss any statistically substantiated differences, the assessment of fungicide uses showed a slight trend in favour of coarse-droplet application. Knewitz et al. observed that coarse-droplet nozzles produced higher initial coatings in a study carried out in 2002. This confirms the results found for many fungicide indications, since in this case the leaf surface as a large target area is able to take sufficient quantities of coarse droplets.

However, further research into the effect of coarse droplets is needed particularly for insecticide indications where the product is applied to smaller target areas and to targets on the back side of leaves. Critical indication for coarse droplet application in arable crops could be the weed control of small targets with vertical orientation applying leaf active herbicides and fusarium control in wheat.

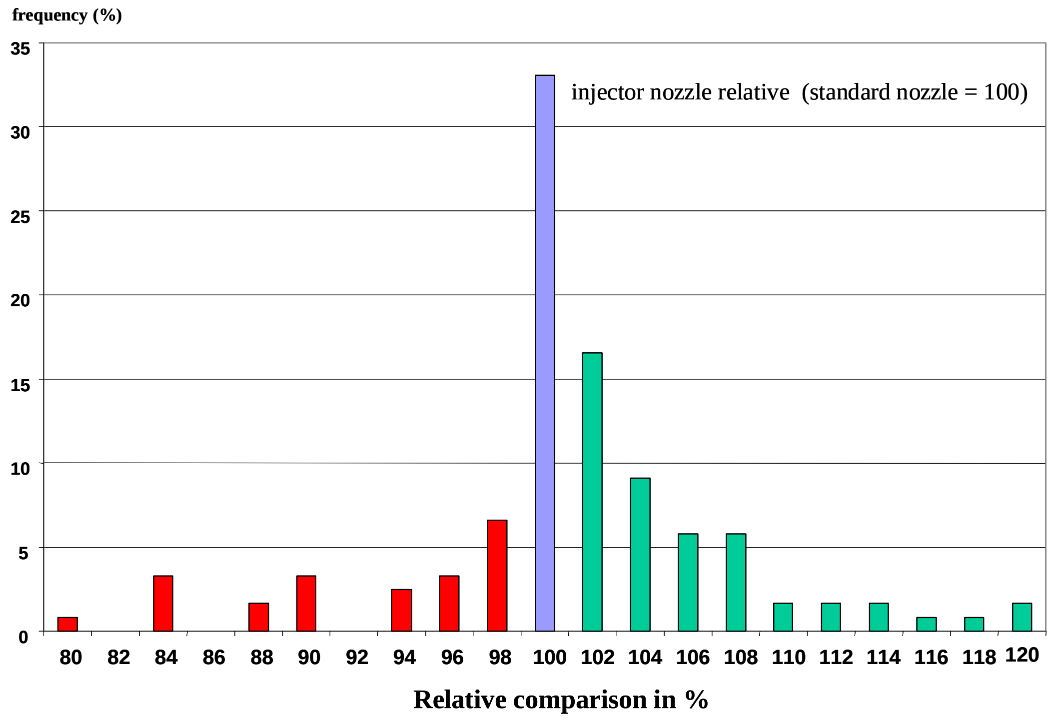


Figure 3: Frequency distribution of results of nozzle comparison trials in apple growing - 130 trials, all indications

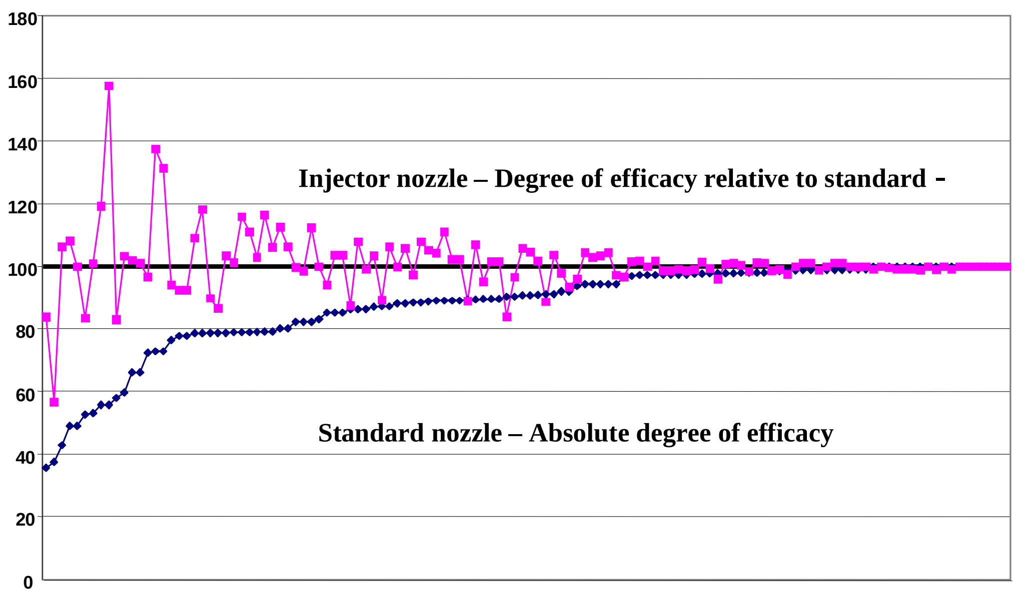


Figure 4: Nozzle trials based on results in apple production - 1995 - 2002
Comparison of the absolute degree of efficacy reached using the standard nozzle with the corresponding relative performance of the injector nozzle

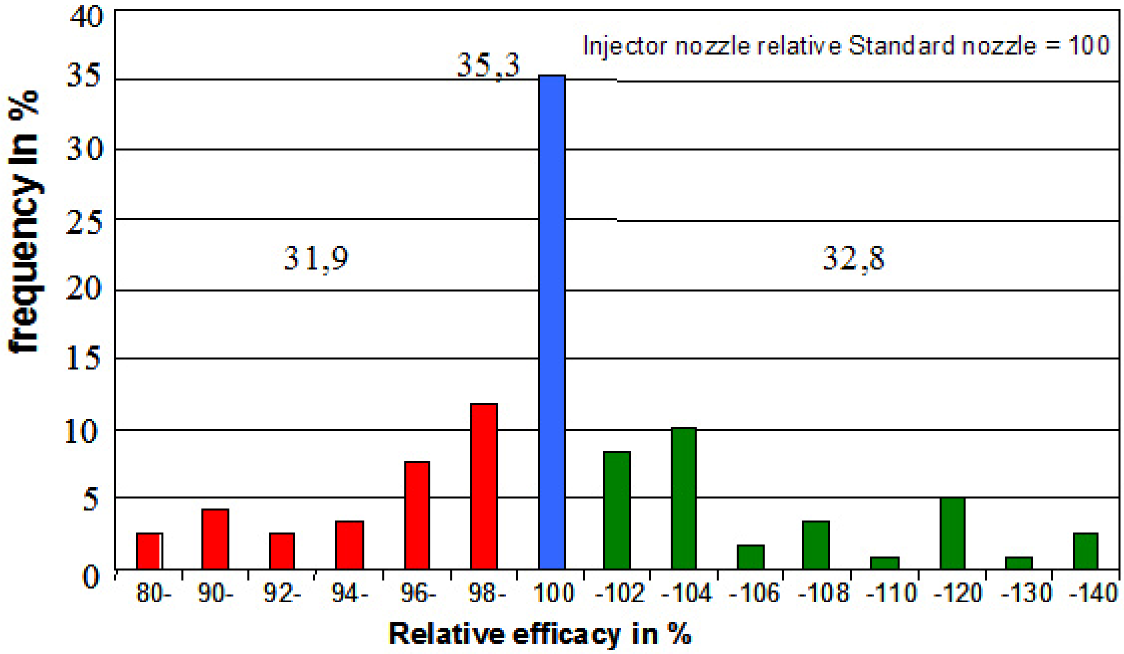


Figure 5: Frequency distribution of results of nozzle comparison trials in arable crops - 146 trials, indications: herbicides (sugar beet, oil seed rape, cereals); fungicides (cereals, potatoes), water volumes 100 – 400 L/ha

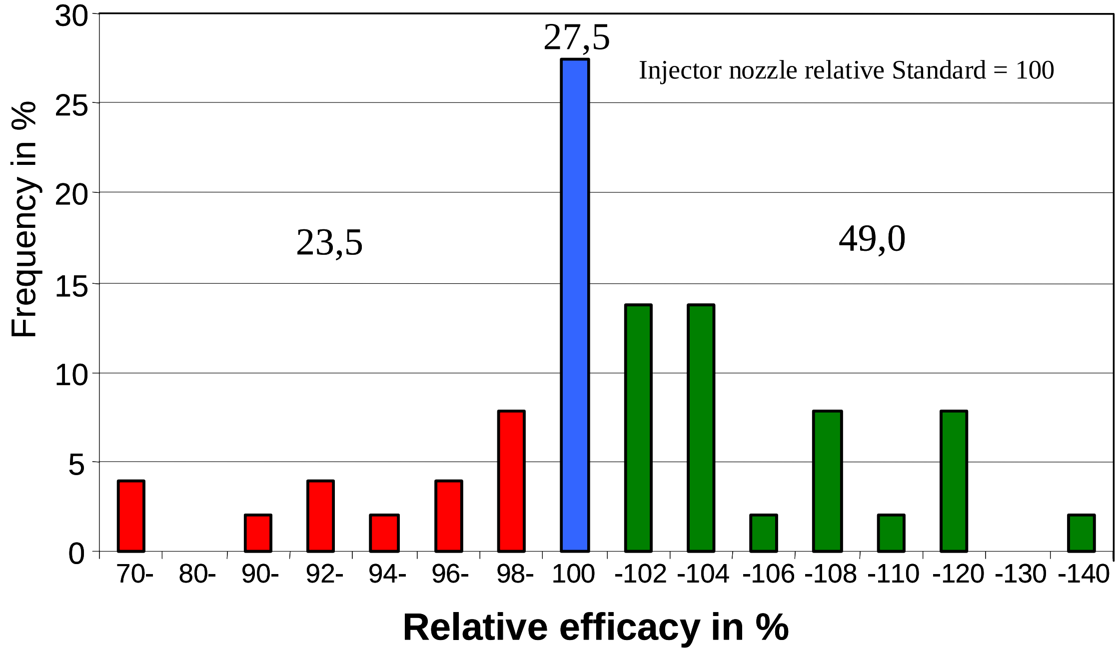


Figure 6: Frequency distribution of results of nozzle comparison trials in arable crops - 77 trials, indications: fungicides (cereals, potatoes), water volumes 100 – 400 L/ha

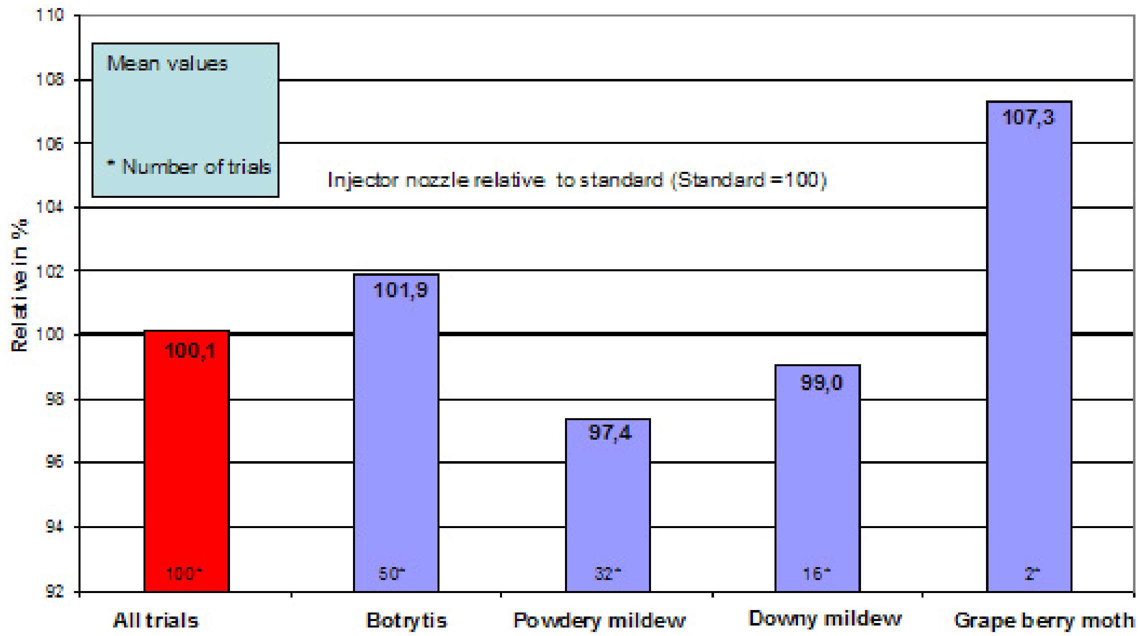


Figure 7: Mean values for nozzle comparisons in various indications in vinery production

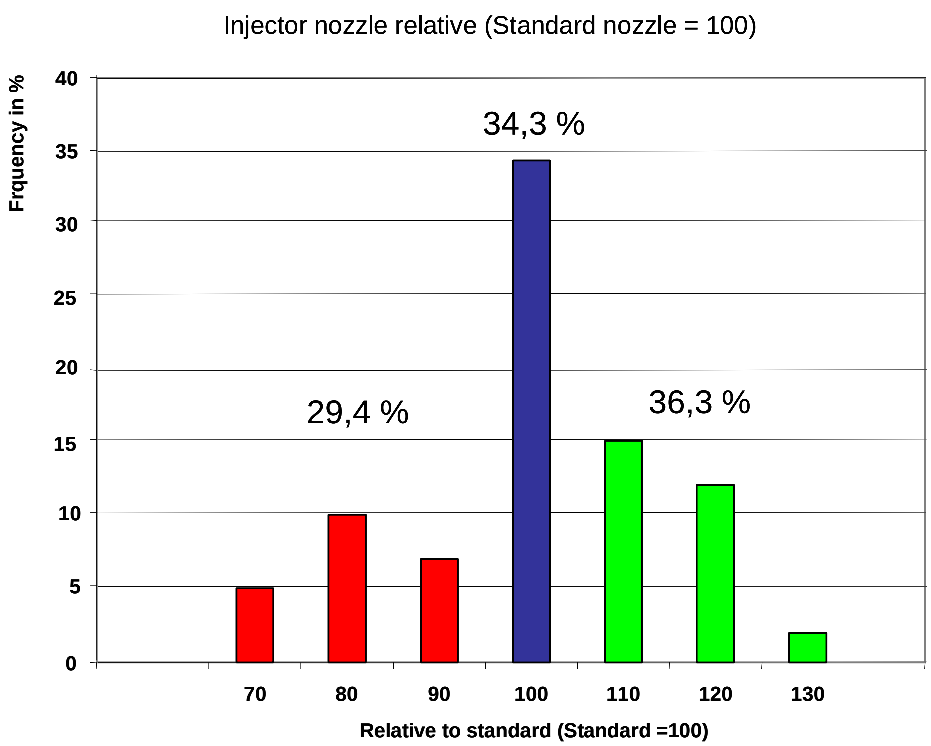


Figure 8: Frequency distribution of results of nozzle comparison trials in vinery production - 100 trials, indications: Botrytis, Powdery mildew, Downy mildew and grape berry moth

Though these summarised trial results were not planned or organised as a series of connected research operations, they clearly indicate that both fine-droplet and coarse-droplet applications of crop protection products are able to produce the desired results in terms of biological efficacy. The principal factors which have an impact on the efficacy of crop protection products are choice of product, timing and weather conditions at the time of application. Of course, this assumes that the technique used is in line with requirements in all essential parameters.

Despite this comprehensive survey of a range of test results from important areas and institutions in Germany, a number of questions remain open and require further investigation. They are:

- influence of the coarse-droplet technique on insecticide / acaricide applications
- Influence of weather conditions at the time of application on optimal droplet size and applied water volumes
- Influence of the mode of action of the crop protection product used on the requirements made on the application technique
- Effects of droplet size on spray spot formation on ripe apples and other fruits
- How far test results can be transposed to other not examined crops.

Overall, this survey confirmed previous research into coarse-droplet application of crop protection products (Frießleben et al. 2000). As the process by which products are deposited on targets when used in the field is so complex, it will not be possible to give any conclusive evaluation of technical issues until enough trials under realistic conditions have been carried out. Tests conducted in the laboratory or greenhouses are not an appropriate basis for recommending application techniques for use in practice. The summarised results support the use of pressure/nozzle combinations with a coarse droplet spectrum or with a spectrum containing only a small proportion of the volume of liquid applied in the form of suspensible droplets that are less than 100µm in diameter. Standard nozzles produce about 17% of the liquid as suspensible droplets compared to less than 2% in the injector nozzle combinations investigated. Most of the trials were conducted using air injector nozzles whose mean volumetric droplet size (MVD) is almost double that of comparable standard nozzles (fig. 1). Nozzles with a coarse droplet spectrum and producing a low proportion of fine droplets are suitable for many applications in terms of their influence on biological efficacy, and can be recommended to growers. In general, the choice of nozzle makes little difference if all the other technical parameters are in optimum.

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