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Distribution of spray applied to a cereal crop and the effect of application parameters on penetration

by

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1. ABSTRACT

A series of trials were carried out, both in the field and in a wind tunnel, to investigate the distribution in a winter wheat canopy of a spray application, to identify the factors which influence the distribution, in particular, the quantity of spray depositing on the lower stem.

Increasing application volume was shown to have no influence on the quantity of active ingredient reaching the lower part of the canopy. Recommendations to increase volumes to improve penetration of a dense canopy cannot, therefore, be justified.

The best application system, of those tested in this study, to achieve high penetration into a canopy, as well as good overall plant deposits, was a small droplet air-induction nozzle operating at 100 L ha^{-1}.

Other factors that influence deposition of spray in the lower part of the canopy are wind speed and potentially boom height. Use of an air-induction nozzle effectively eliminated the effect of wind speed and so would be likely to deliver a more uniform distribution over the canopy. An 80° nozzle also increased penetration, but its effect might be reduced by the need to increase boom height with narrower angle nozzles in order to maintain a uniform distribution.

2. SUMMARY

2.1. Introduction

The performance of an agrochemical application to a crop depends upon achieving appropriate targeting of the spray, i.e. maximising the quantity reaching the appropriate site on the plant. Information about placement within the canopy is not readily available and different sources (such as agrochemical or spray nozzle manufacturers) tend to suggest different solutions. Most commonly, the use of high water volumes is recommended to increase penetration into the canopy, although there is little data to support this. Other suggestions have included increasing pressure, angling sprays and using larger droplets.

The distribution of spray within a canopy will depend upon the canopy structure itself – techniques that increase penetration in a cereal crop, where the structure is relatively upright, are unlikely to increase penetration in a potato crop, for example. This project was, therefore, primarily focused on cereals but the results may also have implications for other crops that have a predominantly vertical structure.

There are a number of situations where penetration into a canopy is important, for example, the application of fungicide for the treatment of eyespot. Under HGCA project 3362, ‘Forecasting eyespot development and yield losses in winter wheat’, a small field trial was undertaken to investigate the possibility of improving penetration into a winter wheat canopy in order to increase the deposit on the lower stem and potentially allow treatments for eyespot to be applied at a later growth stage. This study identified important potential improvements in deposit with particular nozzle designs and that increasing water volumes would be unlikely to improve penetration (HGCA Project Report 491).

A series of investigations were therefore undertaken, both in the field and in the wind tunnel at Silsoe Spray Applications Unit: to investigate the distribution in a winter wheat canopy of a spray application, to identify the factors which influence the distribution, and in particular, to measure the quantity of spray depositing on the lower stem. The hypotheses to be tested were that:

- Increasing application volume would not increase the deposit in the lower part of the canopy
- A more vertical droplet trajectory would increase the deposit in the lower part of the canopy; and
- Small droplet air induction nozzles would give a good level of deposit in the lower part of the canopy.

2.2. Materials and methods

2.2.1. Field experiments

Plots of winter wheat, (variety Oakley) 6 m wide by 8 m long, with 8 m gaps between, were sprayed with a solution containing a non-ionic surfactant at 0.1% by volume, and 2 g L^{-1} of a tracer dye (Green S) using a 24 m boom sprayer.

Treatments were partially randomised and there were five replicate plots per treatment. Following the spray application, 20 plants were taken randomly from each plot, excluding the area 1.0 m from the edge, which were subdivided into two samples, making a total of 10 samples per treatment.

2.2.2. Wind tunnel experiments

Trays of winter wheat (variety Scout) were grown outdoors to growth stage (GS) 37 and arranged in a 4 x 3 array in the wind tunnel underneath a track sprayer with a three-nozzle boom. The trays were 0.3 x 0.25 m and 0.15 m deep. The two central trays were used to obtain samples, with one sample per tray. There were three replicate runs for each treatment, making six replicate samples per treatment.

2.2.3. Sample handling

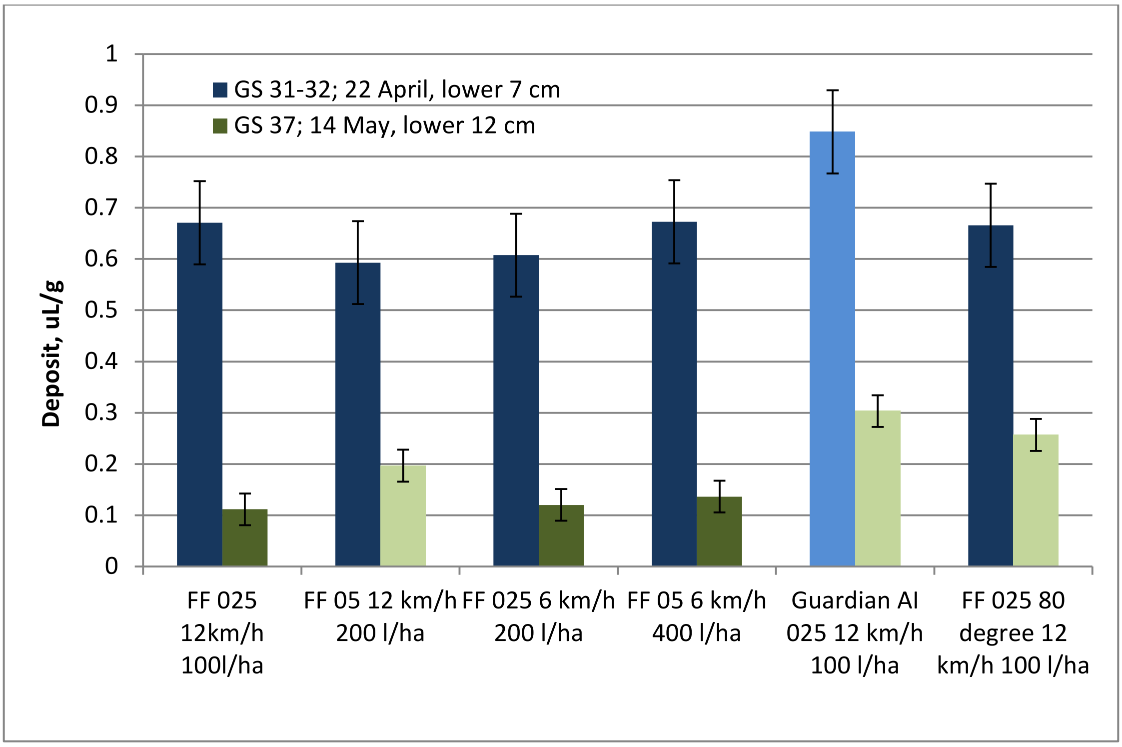
Plants were divided into three sections, bottom, middle and top, and leaves separated from stems. Each bag of samples was stored in cool, dark conditions until analysis. Each sample was weighed, and then a known volume of deionised water was placed in the bag and was shaken to remove the deposited dye. The rinsate was decanted into test tubes and the concentration compared with that of the tank samples using spectrophotometry to determine the quantity of original spray liquid deposited on the lower stems.

Applications were made between BBCH GS 31-and 37 (BBCH, 2001). A range of nozzles were selected to give different volumes and spray characteristics, and combined with different forward speeds (6 – 12 km/h) and boom heights (0.6 – 0.75 m above the crop).

2.3. Results

2.3.1. Initial results from Project 3362 (HGCA Project Report 491)

Measurements of the deposit on the lower stem of wheat plants are shown in Summary Figure 1 for the two growth stages.



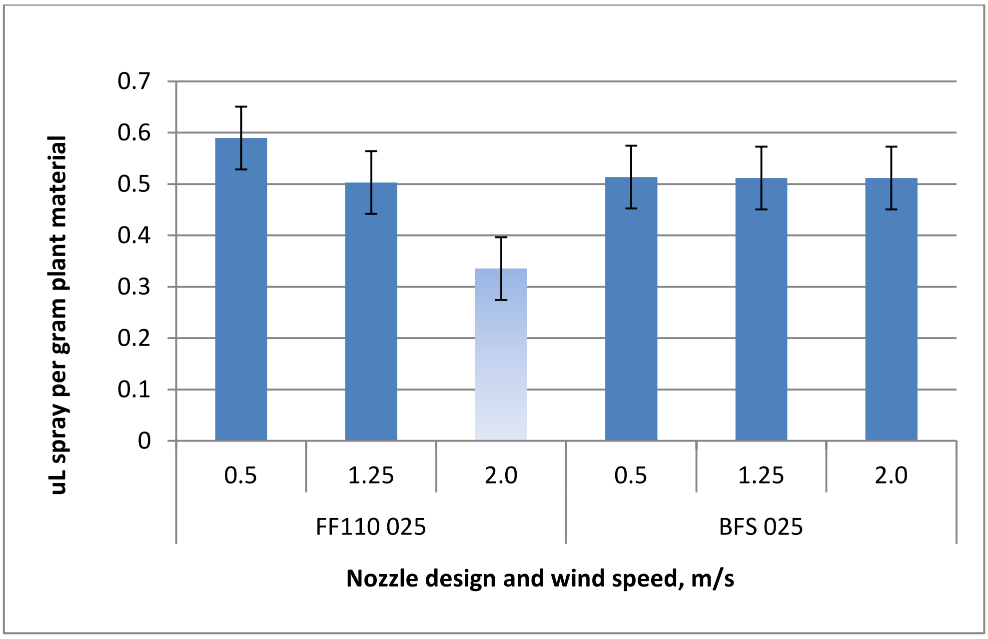
Summary Figure 1. Normalised spray deposit (µL/g fresh weight per 100 l/ha applied) on lower stem of winter wheat plants after an application at GS31-32 (left bars, or colour) and at GS37 (right bars, other colour). Error bars indicate LSD/2. Lighter bars indicate statistically significant differences from the FF025 at 12 km h^{-1} (100 L/ha) at the same growth stage.

2.3.2. Results from wind tunnel tests (2010)

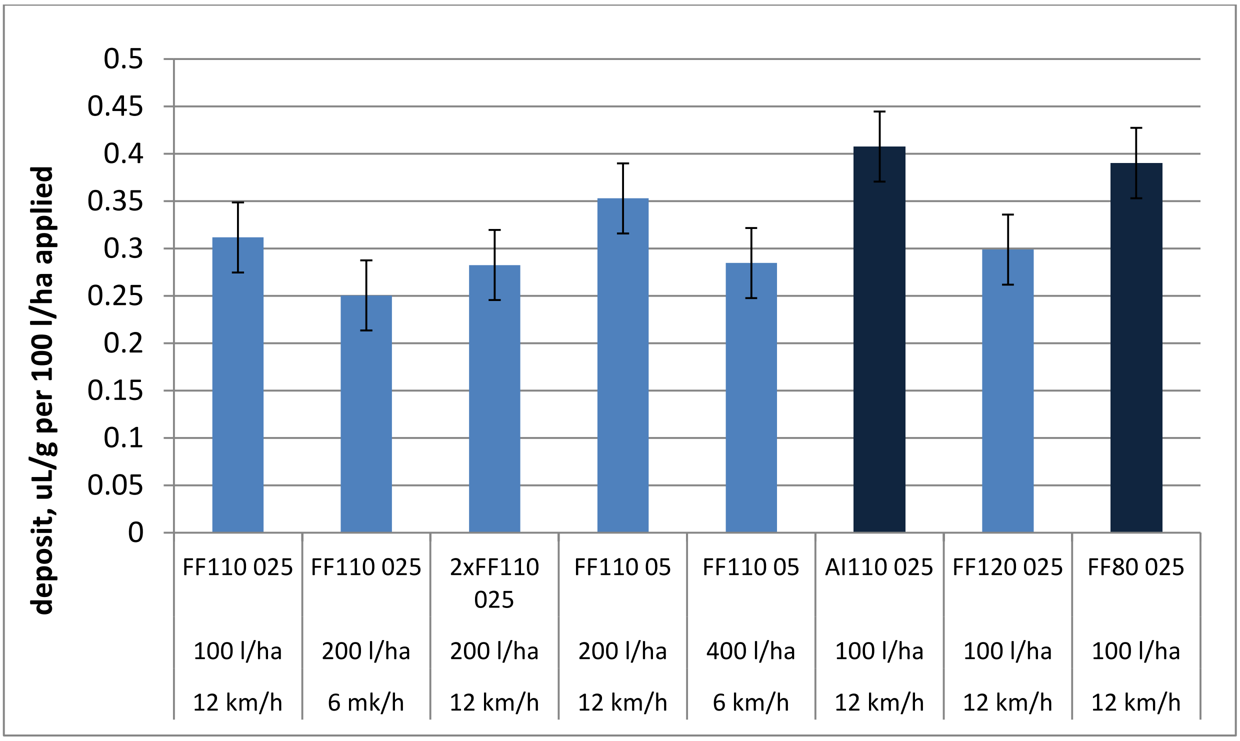
Measurements of deposit on the lower stem of tray-grown plants sprayed in the wind tunnel with a range of wind speeds are shown in Summary Figure 2. This shows that as wind speed increases, the amount of spray reaching the lower part of the canopy is reduced with a conventional nozzle design, but is unaffected when spraying with a small-droplet air-induction nozzle.

2.3.3. Results from field trials (2010)

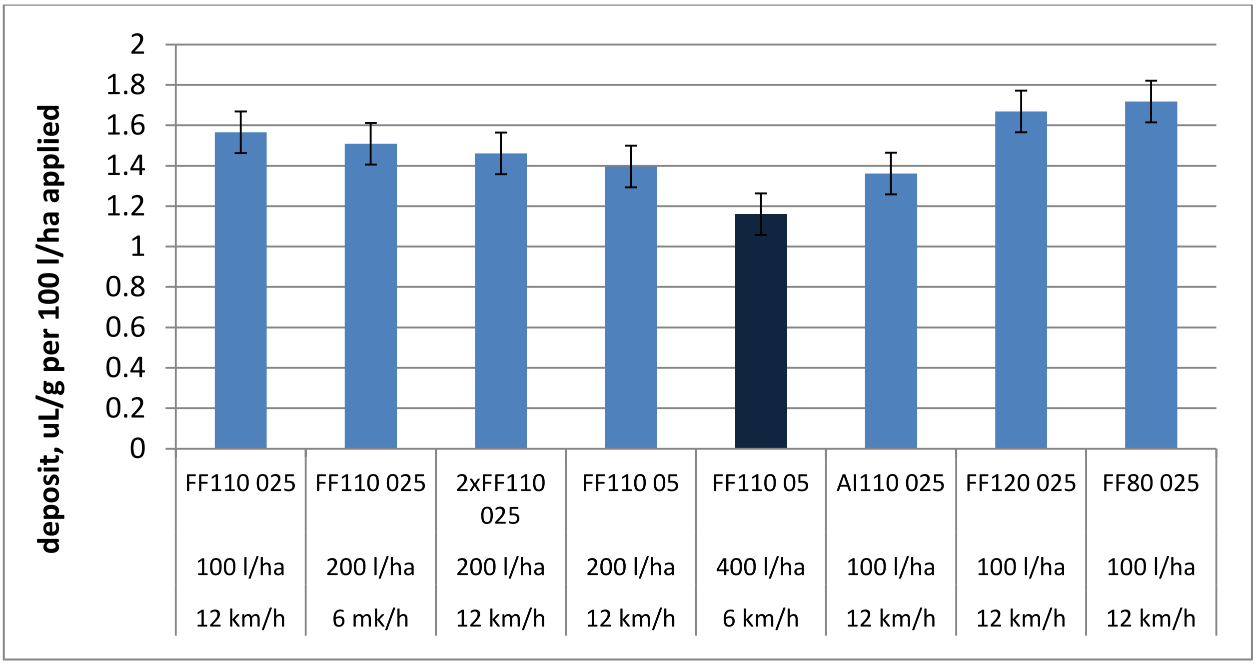
A field trial investigated the effect of increasing water volume from 100 to 400 L ha^{-1} through a combination of nozzle size and forward speed, and also the effect of nozzle design on the deposits within the canopy. Summary Figure 3 shows the deposit on the lower stem, and Summary Figure 4 the deposit on whole plants.



Summary Figure 2. Deposit on lower 100 mm of plants (µL/g fresh weight per 100 l/ha applied) for different nozzles and wind speeds, measured in the wind tunnel. Error bars denote LSD/2. Lighter bars indicate significant differences from the same nozzle in a wind speed of 0.5 m s^{-1}.



Summary Figure 3. Normalised spray deposit (µL/g fresh weight per 100 L ha^{-1} applied) on lower stem of winter wheat plants sprayed in the field at GS37. Error bars indicate LSD/2. Darker bars indicate significant differences from the 110 025 flat fan nozzle at 12 km h^{-1} (100 L ha^{-1}).



Summary Figure 4. Total normalised spray deposit (µL/g fresh weight per 100 L ha^{-1} applied) on whole winter wheat plants sprayed in the field at GS37. Error bars indicate LSD/2 Darker bars indicate significant differences from the 110 025 flat fan nozzle at 12 km h^{-1} (100 L ha^{-1}).

2.4. Discussion

Field trials and wind tunnel tests showed clearly that increasing spray volume did not improve the quantity of spray deposited on the lower parts of plants but did reduce the quantity of spray deposited over the whole plant. This suggests that the proportion of retained spray reaching the lower part of the canopy might be greater at the higher volumes, but this is not sufficient to compensate for the lower deposits overall.

It is common to read label recommendations stating that volumes up to 400 L ha^{-1} should be used to achieve penetration into dense cereal canopies, and there is sometimes uncertainty among spray operators about whether 100 L ha^{-1} would give adequate control. However, the results presented here show that the recommendation to growers to increase volume in order to improve penetration of cereal crops cannot be justified.

The type of nozzle that gave the greatest deposit on the lower part of the canopy in field trials was a small droplet air-induction nozzle. These gave slightly lower deposits on the whole plant which were, although not statistically significant, consistent with other studies with air-included droplets. However, this has been shown in previous work to have no significant reduction in a T2 fungicide performance. We can therefore conclude that an air induction nozzle is likely to give good penetration into a cereal canopy at growth stages 32−37 without risk of compromising the performance of a fungicide application.

Applications at the later growth stage (GS37) resulted in significantly less deposit on the lower stem per gram plant material than at the earlier growth stage (GS31-33): on average 0.19 µL g^{-1} compared with 0.68 µL g^{-1}. This demonstrates that even with the best nozzle and application conditions, a later application cannot achieve the levels of deposit in the lower part of the canopy that an earlier application can achieve, and canopy structure is the most important factor influencing penetration.

Current recommendations in the HGCA nozzle chart indicate a small droplet air induction nozzle and or a medium quality spray, at a volume of 100 – 200 L ha^{-1} would give optimum performance for a fungicide application after GS 32. The findings of this work support this recommendation and, furthermore, suggest that there could be significant advantages to using volumes closer to 100 L ha^{-1} in terms of total deposit retained on the plant. This is likely to give the best coverage of all parts of the plant compared with typical commercially-available nozzle designs.

The performance of a pesticide application does not depend solely on the quantity of active ingredient reaching the target site. The size of droplets may also be an important factor for some products and therefore it is important to validate the findings of this project by undertaking some efficacy testing with commercial products.