Air-assisted spraying in winter wheat: Results of deposition measurements and the biological effect of fungicides against leaf and ear diseases.

Proceedings of an international conference organised by The BRITISH CROP PROTECTION COUNCIL held at the Brighton Centre and the Brighton Metropole Hotel, Brighton, England

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AIR-ASSISTED SPRAYING IN WINTER WHEAT - RESULTS OF DEPOSITION MEASUREMENTS AND THE BIOLOGICAL EFFECT OF FUNGICIDES AGAINST LEAF AND EAR DISEASES.

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ABSTRACT

During three growing seasons the use of air assistance was compared with conventional spraying at two volume levels. The biological effects were determined in a randomized field test with spray concentrations of the active ingredient varying from 0 to 100 % of the dose advised, and volume rates of 100 l ha^{-1} and 200 l ha^{-1}. Deposition was measured at the time of spraying of the winter wheat crop. The total deposition and deposition pattern on the crop was established by washing paper strips and winter wheat leaves from different heights in the crop, using the dye Brilliant Sulfo Flavine (BSF). Biological effects of the sprayings were investigated by quantifying the percentage of the leaf area covered with brown rust (*Puccinia recondita*) and leaf spot (*Septoria tritici*) on the three toplevel leaves. The use of air assistance resulted in a different distribution of the spray in the crop, and a higher emission to the soil surface beneath the crop. Significant differences were found in the biological efficacy between volume rates and dosage. A sprayed volume of 200 l ha^{-1} sometimes resulted in better disease control than 100 l ha^{-1}. Air-assistance was not significantly better. Full dosage and 75% dosage of active ingredient resulted in better disease control than 50 % dosage.

INTRODUCTION

Because of environmental contamination a general reduction in the use of pesticides is required. The aim in The Netherlands is to reduce the use of pesticides by 50% by the year 2000. Drift of spray to surface water next to cultivated land should be reduced by more than 90% (Tweede Kamer der Staten-Generaal, 1991). In accordance with the Multi Year Crop Protection Plan research has been set up to develop improved application techniques for pesticides. Improvements in spraying application techniques can contribute to these goals by better deposition on the leaves and reduction of drift to soil, surface water and air (Tijink, 1993).

If the essential aspects of dose-effect relations of the chemicals are not well understood, this is often compensated by an overdosage of the active ingredient. Reducing the use of chemicals now having top priority, more attention needs to be paid to achieving a better leaf coverage with less chemical. Furthermore, emission of crop protection chemicals is a major problem in chemical crop protection. New spray application techniques might improve the deposition and reduction of drift. In a series of experiments spray-deposition and biological effect were determined in a winter wheat crop using a sprayer equipped with an air-assisted system. In the set up volume rates, the rate of active ingredient and the use of air assistance was compared.

MATERIALS AND METHODS

During three growing seasons (1991-1993) field trials were established in a crop of winter wheat (cv. Obelisk) at Westmaas Research Station. Plots, measuring 12m wide and 25 m long, were marked out in a randomized block design incorporating three replicates. A "Hardi Twin" sleeve boom sprayer was used. For air-assistance the sprayer was operated at its maximum air flow with nozzles kept vertical,as in conventional practice. Because of its ability to be operated without air assistance, the "Hardi Twin" was also used to apply the standard conventional non air-assisted spray treatments, the air curtains on the machine being folded. The following treatments were used with and without air assistance:

Sleeve boom (Hardi Twin) 4110-18 nozzles, 1,7 bar, 200 l ha^{-1}
Sleeve boom (Hardi Twin) 4110-12 nozzles, 1,4 bar, 100 l ha^{-1}
For all treatments tractor speed was 6 kph and boom heights was 0.60 m above crop canopy.

Spray deposition

The trial areas for the deposition measurements were in a strip alongside the field trial. At the time of fungicide application deposition measurements were carried out by adding the fluorescent dye Brillant Sulfo Flavine (BSF) to the spray agent (0.5 g l^{-1} water). The detergent Agral N was added in a concentration of 1 g l^{-1} water to simulate a pesticide formulation. After the spraying the dye was extracted from the leaves or collectors. Collectors used are chromatography paper strips 20 cm long and 2 cm wide folded around leaves, and 100 x 8 cm filter tissues on the soil surface and over the crop canopy. Collectors were placed systematically on three places across the sprayer boom. A single spray pass was made across each target. The rate was measured by fluorimetry and expressed per surface area of the collector. The measured deposits were expressed as percentage of the application rate of the sprayer (spray dose). After log-transformation results of the deposition measurements were statistically evaluated using Genstat statistical software (Payne, 1993). In addition to absolute deposition (quantity of chemical), the results included the coverage and the droplet spectrum on the target area. For this part of the research, video recordings were made of the spray deposition on water sensitive paper that was suspended in the crop. The video recordings were analyzed by means of vision technology. Results are not reported.

Biological effect

Biological effects of the sprayings were investigated in randomized field trials during three following growing seasons (1991-1993). In each growing season the level of infected leaf-area of the plants with *Puccinia recondita* and *Septoria tritici* was measured. Levels of disease in the crop were recorded at time of application and at weekly intervals until desiccation of the top leaf. This was done by taking fifteen randomly selected main shoots per plot, assessing leaf diseases on the upper three leaf levels as percentage leaf area affected using key-figures.

A single fungicide treatment, (a mixture of 1 l Corbel + 0,5 l Sportak ha^{-1}, (1991 and 1992) or 1.25 l ha^{-1} Sportak Delta in 1993), was applied at flowering GS 65-69 (Zadoks). Dosages varied from 100%, 75% to 50%. An untreated control was also included. The total field received normal farm inputs for fertilizer, weed control and growth regulation.

RESULTS

Spray deposition

From the deposition measurements in 1992 it becomes clear that 100 l ha^{-1} gave proportionally higher rates of deposition on the whole wheat plant than 200 l ha^{-1} (Table 1). With 100 l ha^{-1} there was no difference between with and without air-assistance. At 200 l ha^{-1} there was a difference between with and without air assistance in deposition on the whole plant. In general the rating could be 200 l ha^{-1} least, 100 l ha^{-1} with/without air equally more and most with 200 l ha^{-1} with air-assistance. At 200 l ha^{-1} there was a difference in deposition on the second leaf between with and without air-assistance. With 100 l ha^{-1} this was only significant at the third leaf. Deposition on the top leaf between treatments was not statistically significant (P<0.05). On the second and third leaf 100 l ha^{-1} with and without air assistance deposited proportionally more spray volume than 200 l ha^{-1}. Deposition on the top, second and third leaf was different for all spraying systems.

TABLE 1. Median (top- and underside) deposition on upper, second and third leaf as % of sprayed volume, results 1992.

Volume (l ha-1)	Air-assistance	Leaf level		
		Upper	Second	Third
100	none	10.3	5.8	5.4
100	full	11.6	5.5	3.2
200	none	9.5	3.7	1.9
200	full	10.7	5.1	2.8

LSD (P<0.05) = 1.5

In 1993 the emission to the soil surface with 100 l ha^{-1} was more with air-assistance than without air-assistance (not shown). At 200 l ha^{-1} the differences in soil deposition were not statistically significant (P<0.05). More spray liquid deposited on the top side of the leaves than on the under side. There was a difference in deposition on the three leaf levels. On the top side of the leaf the average deposition differed for all three leaf levels. On the bottom side the average deposition on the upper and second leaf differ from the third leaf. In total more deposition was found on the wheat leaves with air-assistance than without air-assistance (Table 2). With air-assistance more deposition was measured on the top side of the leaves than without air-assistance, especially on the top leaf and to a lesser extent on the second leaf. On the under side of the leaf air-assistance deposited no more than without air-assistance. A volume of 200 l ha^{-1} gave proportionally more deposition on the top side of the leaves than 100 l ha^{-1} with no difference between volumes on the under side of the leaves. Compared to conventional application, the deposition pattern for both 100 l ha^{-1} and 200 l ha^{-1} was for air-assistance different on the top and second leaf level ($P<0.05$) and for the 200 l ha^{-1} on the third leaf level ($P<0.10$). Air-assistance gave slightly deeper penetration in the plant canopy.

TABLE 2. Median (top- and underside) deposition on upper, second and third leaf as % of sprayed volume, results 1993.

Volume (l ha-1)	Air-assistance	Leaf level		
		Upper	Second	Third
100	none	6.8	4.3	2.7
100	full	8.5	6.0	3.3
200	none	6.7	4.1	2.0
200	full	8.4	6.3	3.1

LSD ($P<0.05$) = 1.4

Biological effect

During the individual growing seasons leaf diseases occurred in untreated as well as in treated plots; in general disease levels were low in 1991 and 1992 and moderate in 1993. In all three years all spraying systems and dosages reduced the mean level of *P. recondita* and *S. tritici* significantly ($P<0.05$) (not shown). In 1991 *P. recondita* and *S. tritici* reacted identically to effects of spraying systems, volumes and dosages (not shown). There was an effect of volume rate on all three leaf levels during recording period, and a dosage effect on second leaf at the last recording day, three weeks after spraying.

In 1992 for *P. recondita*, at the first recording day there was an effect of air-assistance on the top and third leaf (not shown). This vanished on later recording dates and after 3 weeks only a dosage and a volume effect remained on the top and second leaf (Table 3). For *S. tritici* a dosage (not shown) and volume effect was significant on the top and second leaf three weeks after spraying.

TABLE 3. Mean % leaf area affected by *S. tritici* (S) and *P. recondita* (P) on the last recording day before desiccation of the different leaf levels, 2-4 weeks after spray application, results of 1992.

Volume (l ha-1)	Air-assistance	Leaf level					
		Upper		Second		Third	
		S	P	S	P	S	P
100	none	6.1	12.7	46.0	2.2	16.7	0.3
100	full	8.6	13.5	44.3	2.1	14.8	0.4
200	none	2.0	7.5	36.7	1.0	19.5	0.2
200	full	4.1	10.3	37.7	1.1	15.4	0.5
LSD ($P < 0.05$)		6.4	5.8	10.4	0.8	4.9	0.3

In 1993 4 weeks after spraying there was an effect of dosage (not shown) and volume rate on *S. tritici* on the upper wheat leaf. Initially there was an effect of air-assistance on the second leaf (not shown) which vanished during the recording period and only a volume rate effect remained at the last recording day, 5 weeks after spray application (Table 4). On the third leaf a volume effect was significant (P<0.05). For *P. recondita* a dosage effect was significant on the upper and second leaf (not shown). Volume rate had an effect on the second and also on the third leaf.

TABLE 4. Mean % leaf area affected by *S. tritici* (S) and *P. recondita* (P) on the last recording day before desiccation of the different leaf levels, 2-5 weeks after spray application, results of 1993.

Volume (l ha-1)	Air-assistance	Leaf level					
		Upper		Second		Third	
		S	P	S	P	S	P
100	none	17.2	5.7	26.2	3.5	16.6	17.5
100	full	19.0	6.8	26.5	2.3	17.9	22.3
200	none	14.6	7.1	21.9	2.1	11.5	14.5
200	full	13.5	7.2	21.1	1.6	13.1	8.9
LSD ($P < 0.05$)		6.2	4.4	5.4	1.1	4.9	8.0

In general, conventional application at 200 l ha^{-1} had the best control of *P. recondita* in 1992 irrespective of dosage level. For *S. tritici* best protection was obtained by 200 l ha^{-1} by both conventional and with air-assisted spraying. In 1991, 200 l ha^{-1} sprayed conventionally and with air assistance both gave generally better control of both *S. tritici* and *P. recondita*. In 1991, 100 % dosage resulted in better disease control than 75% and 50%. A reduced dosage of 75% gave in 1992 results as good as the full dose on *P. recondita*. On *S. tritici*, the full dose was always better than reduced dose on all three leaf levels. In 1993, both full and 75% dose gave equally better results than 50% dose on both *S. tritici* and *P. recondita*.

DISCUSSION

In 1992, but not 1993, a volume of 100 l ha^{-1} had a higher deposition on the second and third leaf than 200 l ha^{-1}, with no difference between with and without air assistance. The total deposition on the wheat plants was significantly different for air-assisted and conventional spraying. The use of air assistance resulted in better penetration of the spray in the crop, resulting in a more evenly spread distribution over the crop. However air-assistance can also result in a higher emission of spray liquid onto the soil beneath the crop.
A relationship between deposition pattern of the used spraying systems and biological efficacy was difficult to find. Some similarities occurred, but a higher deposition rate does not implicitly mean better disease control. There is a possibility of using reduced dosage for disease control depending on the spraying system. As found by Jørgensen & Nielsen (1992) reduced dosages had considerably less effect on disease control. Similar effects of deposition rate with different application techniques on biological efficacy against rust in wheat was found by Haden (1985). Results from field trials done by Lockley (1993) seem to be in agreement with our findings. Based on a single fungicide spray conventionally applied 200 l ha^{-1} compared well with new developments.

ACKNOWLEDGEMENT

The authors thank Westmaas Research Farm for allowing field work on their farm, Nel Hüsers (PAGV) for typing huge amounts of data and Wim van den Berg (PAGV) for operating Genstat statistical analysis package.

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