A VOLATILIZATION CHAMBER FOR THE DETECTION OF VOLATILE LOSS OF HERBICIDES

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Summary A volatilization chamber was constructed to measure volatile loss of herbicides. To demonstrate the ability of the volatilization chamber to detect and quantitate volatile loss, a new trifluralin emulsion in water (EW) formulation and trifluralin emulsifiable concentrate (EC) were assessed. The volatile loss of trifluralin when sprayed onto soil was measured from within the volatilization chamber and then compared to two methods currently used (a laboratory bioassay and a field bioassay). The trifluralin EW was significantly less volatile than the trifluralin EC when assessed by each method.

The volatilization chamber was more efficient in producing results than either the laboratory or field bioassay with savings in time, labour and resources. The volatilization chamber provided a controlled environment (air flow, temperature and relative humidity) for the accurate measurement of trifluralin volatility, while the rate of volatile loss for trifluralin in laboratory and field bioassays are probably affected by factors which are not controlled.

INTRODUCTION

The dissipation or volatilization of herbicides from their target into the atmosphere is a major source of loss (Taylor and Spencer 1990). In hot humid and windy weather 80–90% of herbicide activity may be lost within a few days (Taylor and Glotfelty 1988). As a result large herbicide doses are often applied to compensate for this loss. The possibility of off target damage to susceptible crops and other plants may also prevent or restrict the use of these chemicals.

Our research program specializes in the development of more efficient and safer herbicide formulations. To date the magnitude of the reduction in volatility of soil applied herbicides is assessed with bioassays. However we have developed a volatilization chamber (Figure 1) to replace the existing methods for measurement of herbicide volatility.

The volatilization chamber controls the temperature, humidity and air flow passing over plants or soil. The volatilization chamber maintains a constant environment which provides the opportunity to model volatile loss of herbicides. The air which passes over the treated plants or soil is sampled at intervals and analysed quantitatively for herbicide concentration with a gas chromatograph (GC). The volatilization chamber and GC provide a fast quantitative measurement of volatile loss from soil or plants. The volatilization chamber assists in the development of low volatile formulations and the collection of data to support registration and publicity claims. We expect the volatilization chamber will greatly increase the knowledge of herbicide volatilization and provide an accurate and efficient method for assessment of volatile loss from herbicides.

In this paper the volatility of a new emulsion in water (EW) trifluralin was compared with the commercial emulsifiable concentrate (EC) of trifluralin by measurement with laboratory and field bioassays and the volatilization chamber. The results for each method were compared.

MATERIALS AND METHODS

Laboratory bioassay Mallee Sand was used for laboratory experiments. Coarse sand, fine sand, silt, clay and organic matter made up 0.617, 0.328, 0.0071, 0.053 and 0.0098 g g^{-1} soil, respectively. The pH of a 1:5 soil-water suspension was 6.6.

Volatilization of trifluralin was measured by spraying eight concentrations of trifluralin onto Mallee Sand contained in two sets of pots, each pot was filled with 600 g of soil (0.1 g water g^{-1}, oven dried at 40°C) and sprayed with a laboratory tracksprayer which delivered 64 L ha^{-1} at a pressure of 200 kPa from three flat fan nozzles (Spraying Systems™ 11001). Nozzles were spaced at 50 cm intervals across the boom which traversed the pots at 6 km h^{-1}. The height of the boom was set at 35 cm above the soil surface.

Each set included seven replicates (pots) at each concentration. One set of replicates was incorporated (mixing the herbicide into the soil) immediately after spraying. The trifluralin on the soil surface of the remaining set of pots was left to volatilize in the laboratory for 48 h then incorporated, the temperature was recorded for this period (Table 1).

Once the soil had been mixed 150 g was removed, the soil remaining in the pot was levelled and 25 ryegrass (*Lolium rigidum*) seed sown and the 150 g of soil replaced. After sowing the pots were watered and placed into a CE room (12 h day at 22°C and 12 h night at 12°C) for 10 days. Plants were watered once daily and the emergence of ryegrass assessed 10 days after sowing. An

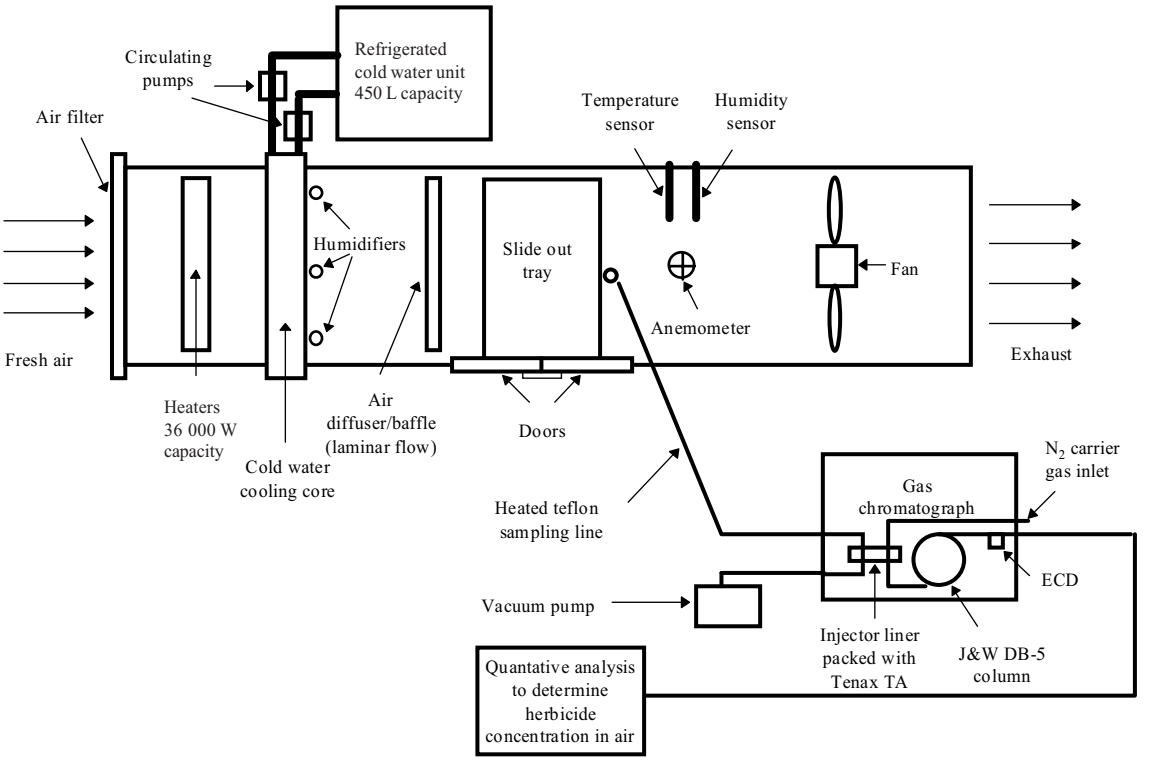

Figure 1. A diagram of the volatilization chamber. Note: not to scale.

Table 1. Ambient maximum and minimum temperatures during the volatilization period for the trifluralin laboratory and field bioassay.

Bioassay	Day	Maximum temperature (°C)	Minimum temperature (°C)
Lab	1	30	12
	2	32	11
Field	1	31	16
	2	36	20

ED50 (effective dose at which emergence is reduced by 50% of controls) was calculated (with a fitted logistic dose response curve) to estimate the amount of herbicide in the soil for each incorporation treatment (0 and 48 h).

Field bioassay The field experiment was conducted at the Victorian Institute for Dryland Agriculture, Horsham. We were unable to conduct the field experiment on Mallee Sand due to the requirement for irrigation. Trifluralin was applied to a grey self mulching clay (Ug 5.33, Stace *et al.* 1968) with a field spray unit which delivered 64 L ha^{-1} of spray solution at 6 km h^{-1}. The experiment consisted of two herbicides (EC and EW), two incorporation times (0 and 48 h), one application rate (400 g a.i. ha^{-1}) of four replicates. The 6 × 15 m plots were incorporated (to mix the herbicide into the soil) by two passes along the plots with long tyned harrows. The experimental plots were sown with wheat (*Triticum aestivum* cv. Meering at 65 kg ha^{-1}) and oversown with ryegrass (*Lolium rigidum* at 1000 seeds m^{-2}) eight days after spray application. The emergence of the wheat and ryegrass assessed 20 days after sowing.

The temperature was recorded over the volatilization period (Table 1). The field bioassay was carried out during summer to maximize volatilization of the trifluralin.

Volatilization chamber Volatilization measurements of trifluralin were made from Mallee Sand. The soil (0.1 g water g^{-1} oven dried at 40°C) was packed into a tray 50 × 50 × 3 cm and sprayed with trifluralin (100 g ai ha^{-1}) with a laboratory tracksprayer. Once sprayed, the tray was sealed in a container and transferred to the volatilization chamber. The volatilization chamber was set at 23°C, 30 % RH and the air flow at 1.4 m s^{-1}. The inlet of the heated (100°C to prevent condensation) sample line was placed immediately behind the tray close to the soil surface.

A vacuum drew the sample through Tenax TA packed in a PSS (programmable split splitless) injector liner for a pre-determined time. The injector was heated to 300°C and the trapped herbicide was swept onto the GC column with N_2 gas. The GC (AutoSystem, Perkin Elmer) was fitted with a J&W DB-5 column (15 m 0.53 mm, 1.5 µm film thickness) and detected with an electron capture detector. Trifluralin was trapped onto the Tenax TA at intervals from 0–10, 20–40, 50–80, 90–130, 140–190 and 200–260 minutes, over 4.3 h.

Statistics Non-linear regression analysis was used to fit a logistic dose response curve (Striebig 1988) to the laboratory bioassay results and an ED50 was then calculated. The data for the field bioassay was analysed with an analysis of variance and was transformed by taking the square root of ryegrass emergence. An analysis of variance was conducted to compare the sum of trifluralin detected for the EC and EW with the volatilization chamber.

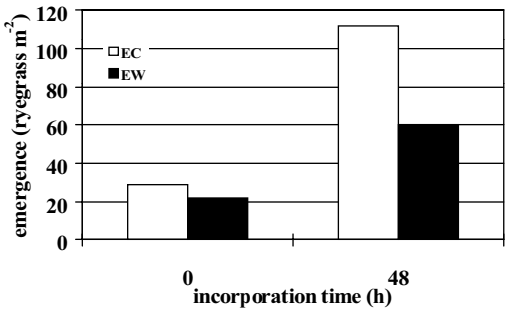

Figure 3. A comparison of the activity of trifluralin EC and EW on ryegrass emergence when trifluralin was incorporated immediately[A] or after 48 ha in a field bioassay. ([A] Comparisons between treatments were made with transformed results P<0.05)

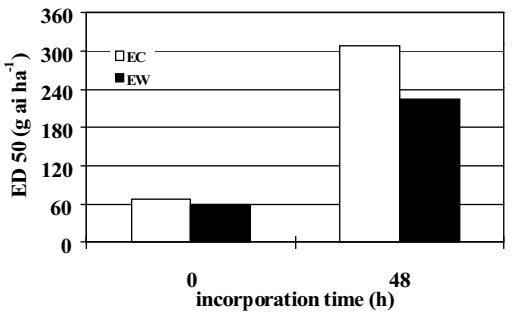

Figure 2. A comparison of the activity of trifluralin EC and EW on ryegrass emergence when trifluralin was incorporated immediately[A] or after 48 h[B] in a laboratory bioassay. [A] Not significantly different P>0.05, [B] significantly different P<0.05.

RESULTS

Laboratory bioassay The ED50 of trifluralin EC and EW were similar when incorporated immediately which demonstrated equal efficacy (Figure 2). At the 48 h incorporation the EW was 27% more active than trifluralin EC which demonstrates the EW was less volatile than the EC.

Field bioassay Trifluralin EW reduced emergence of ryegrass 24% more than the trifluralin EC when incorporated immediately after the soil was sprayed (Figure 3). When incorporation was delayed for 48 h, 45 % less ryegrass emerged when treated with trifluralin EW compared with the trifluralin EC (Figure 3). These results support those from the laboratory experiment.

Volatilization chamber The cumulative amount of trifluralin detected from soil sprayed with trifluralin EC was 85 g, which was significantly greater (26%) than that detected for the EW (Figure 4, time 4.3 h).

Comparison of methods Experiments conducted in the volatilization chamber used 83 kg less soil (Table 2) and 25 less hours of labour than the laboratory bioassay. The time to complete the experiment was reduced from 12 days for the laboratory bioassay and 30 days for the field bioassay to two days for the volatilization chamber experiment.

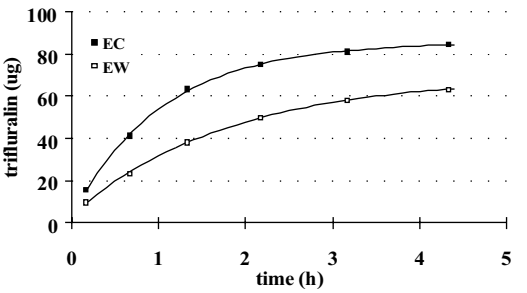

Figure 4. A comparison of the cumulative amount of trifluralin in air sampled at intervals from the volatilisation chamber for the EC and EW over 4.3 h.

Table 2. Time and soil required for the laboratory bioassay, field bioassay and the volatilization chamber for trifluralin EC and EW.

Experiment type	Amount of soil	Time (d)	Labour (h)
Laboratory	110 kg	12	31
Field	180 m^2	30	20
Vol chamber	27 kg	2	6

DISCUSSION

The volatility of trifluralin EW was significantly less than trifluralin EC when measured with each method. The laboratory bioassay demonstrated that trifluralin EC lost 27% more activity than trifluralin EW when incorporation was delayed for 48 h (Figure 2). The field bioassay was conducted in summer to maximize volatile loss for trifluralin. The emergence of ryegrass in plots treated with trifluralin EW and incorporated after 48 h was 45% less than plots treated with trifluralin EC (Figure 3). Lastly, the amount of trifluralin EW detected (Table 2) in air sampled from within the volatilization chamber was 25% less than the EC (Figure 4).

The volatilization chamber was more efficient in producing results than either the laboratory or field bioassay with savings in time, labour and resources. The control of air flow, temperature and RH enables a quantitative measure of trifluralin in air sampled to begin immediately after spray application. Existing methods (laboratory and field) require the trifluralin to remain on the soil surface for 48 h before incorporation, where it can be affected by factors which are not controlled, i.e., UV degradation, air flow, temperature and RH. These factors limit accurate measurement of volatile loss for herbicides with laboratory and field bioassays. The volatilization chamber can model and repeat air flow, temperature and humidity throughout the year to detect volatile loss of herbicides.

The research program is situated at Horsham in the Victorian wheat belt, in the past it has been difficult to assess herbicides in different climates. The volatilization chamber provides our research program with ability to identify factors which affect the volatilization of herbicides. The knowledge gained will increase the efficiency and effectiveness of existing or new volatile herbicides and how we apply them in the environment.

Preliminary research on volatile loss of trifluralin conducted with the volatilization chamber suggests that by increasing temperature the rate of volatile loss is also increased. Further experiments are continuing in this area.

ACKNOWLEDGMENTS

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