Nitrogen loss from top-dressing fertilisers to wheat

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Aim

To measure nitrogen loss (as ammonia) from volatilisation after top-dressing wheat crops grown on two soil types: sandy loam in the Mallee and Wimmera clay, using different fertiliser types and application rates.

Take home messages

- *Volatilisation losses were small on Mallee sandy loam at Walpeup where 4mm of rain fell two days after fertiliser application*
- *Volatilisation losses from the application of urea to Wimmera clay was as high as 26 percent with small rainfall events (< 4mm) in the 20 days after application*
- *Significant nitrogen losses were experienced when ammonium sulphate and liquid UAN were applied to Wimmera clay. Both products lost 12 percent of applied*

Method

Field experiments measuring ammonia losses were conducted in 2008 at two Victorian sites:

- A sandy loam with pH 7.1-8.1 at the DPI Mallee Research Station, Walpeup, in late August;
- A Wimmera clay with pH 7.7 at Longerenong College (20km northeast of Horsham) in September.

There were two experiments at Longerenong with different fertiliser timings (Experiment 1 and Experiment 2).

50m diameter circular plots were top-dressed with nitrogen (N) fertilisers and measurements of ammonia volatilisations made using duplicate passive chemical samplers placed at a 1.6m height in the centre of the plots.

Duplicate samplers were located upwind of the plots to measure background concentrations of ammonia.

Plots were spaced at least 100m apart to avoid ammonia interference between treatments.

Samplers were initially changed every one to two days and then with less frequency as the experiments progressed.

The sites were sown to wheat and the canopy was quite open at the time of treatment application.

Fertiliser was applied to the plots by hand. Four fertiliser types were used:

- Granular urea (U)
- Green Urea™ (GU) – a granular urea product coated with a urease inhibitor to slow volatilisation
- Urea-ammonium nitrate (UAN) – a liquid nitrogen fertiliser
- Ammonium sulphate (AS)

Application timing and rates for each experiment are outlined in Table 1.

Table 1. Fertiliser treatments applied at the Walpeup and Longerenong experiments.

Treatment	Product	Application timing	Method	N rate kgN/ha
Walpeup				
46 U	Urea	19 August	Top-dress	46kg N
GU	Green urea	19 August	Top-dress	46kg N
UAN	Urea-ammonium nitrate	19 August	Spray*	46kg N
Longerenong Experiment 1				
92 U	Urea	3 September	Top-dress	92kg N
46 U	Urea	3 September	Top-dress	46kg N
AS	Ammonium sulphate	3 September	Top-dress	46kg N
UAN	Urea-ammonium nitrate	3 September	Spray*	46kg N
Longerenong Experiment 2				
92 U	Urea	10 September	Top-dress	92kg N
46 U	Urea	10 September	Top-dress	46kg N
AS	Ammonium sulphate	10 September	Top-dress	46kg N

** UAN applied with a hand-held boom. Product applied to crop leaves and soil as canopy was quite open at the time of application.*

Results

Moisture content of the topsoil at both sites was below wilting point with 1-4 percent moisture at Walpeup (sandy loam) and 16 – 27 percent at Longerenong (clay).

Maximum temperatures ranged from 12-20°C at Walpeup, 14-26°C in Experiment 1 and 14-30°C in Experiment 2 at Longerenong (Figure 1a, b and c). Walpeup received a small amount of rain (4.2mm) three days after fertiliser application, then no rain until 13mm fell over days 12 and 13 after fertiliser application (Figure 1a).

At Longerenong, there were a few very light showers (< 3mm) over the duration of Experiment 1; mostly occurring in the second week after application. Rainfall totals were similar in Experiment 2 but of highest frequency during the first week after application (Figure 1b and c).

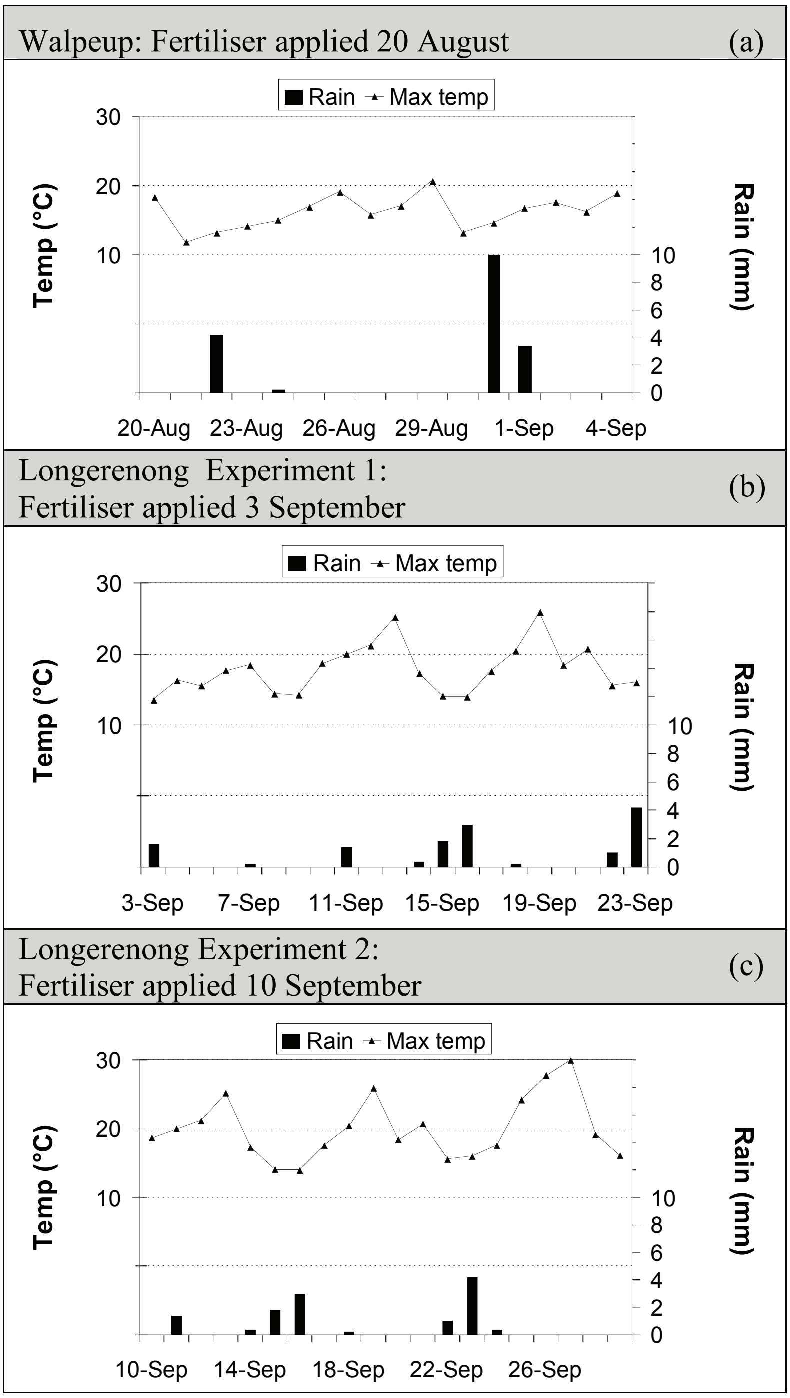


Figure 1. Weather conditions following application of N fertilisers at (a) Walpeup, (b) Longerenong Experiment 1 and (c) Longerenong Experiment 2.

At Walpeup 2.2kg N/ha (4.7 percent of applied N) was lost from the 46U treatment between 20 August and 4 September. No ammonia measurements from GU and UAN were taken from 28 August to 4 September due to a storm causing the samplers to fall down. Only 1.0 percent and 1.3 percent of applied N was lost from GU and UAN respectively up until 28 August (Table 2).

In both experiments, the rate of ammonia loss and total loss of N at Longerenong (Figures 1b and c) was greater for the two urea treatments than the AS and UAN treatments. Ammonia losses twenty days after fertiliser application were between 13-26 percent of applied N from the four urea treatments in Experiments 1 and 2. Sixteen days after the application of AS, 12 percent of applied N had been lost to volatilisation in Experiment 1, but only 2.8 percent was lost in a twenty day period in Experiment 2. Twelve percent of N applied as UAN was lost after 16 days in Experiment 1 (Table 2).

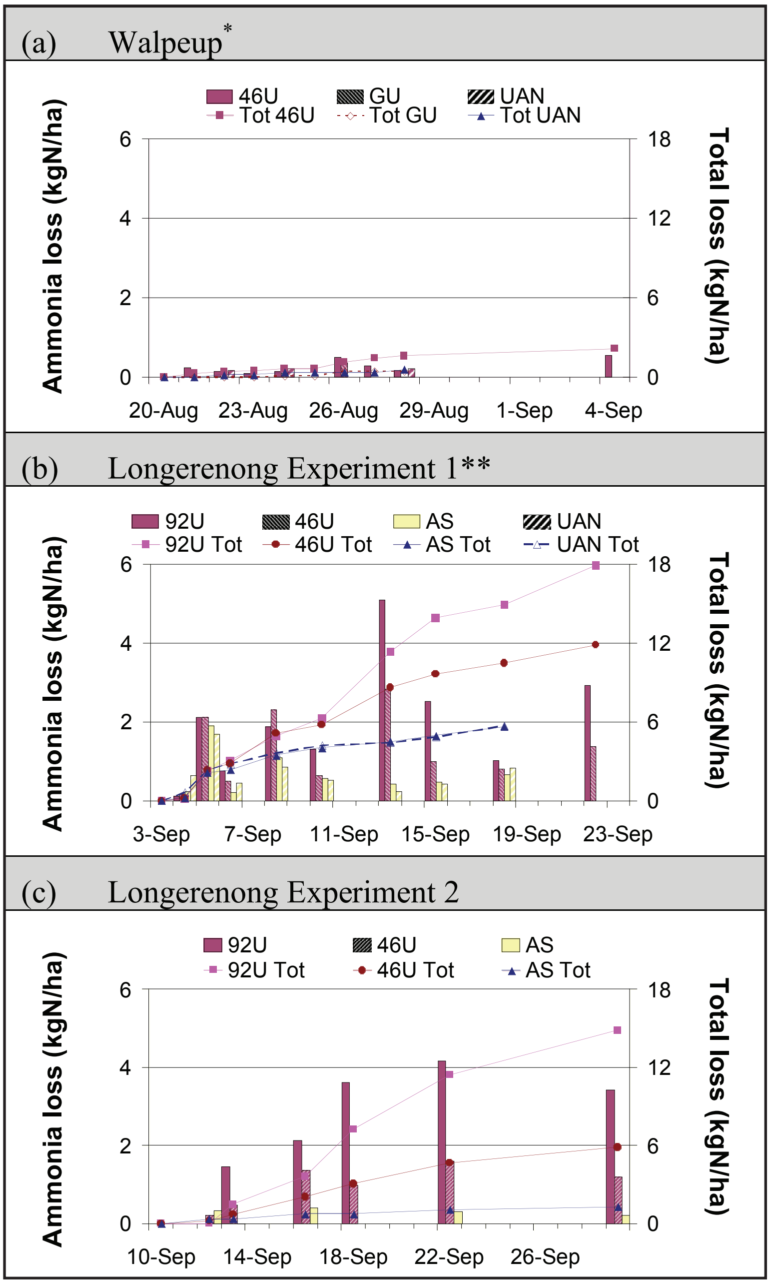


Figure 1. Daily and cumulative ammonia losses (kg N/ha) for the (a) Walpeup and (b) and (c) two Longerenong experiments.

** Storm damage prevented measurements of UAN and GU losses at Walpeup after 28 August.*

*** Measurements of AS and UAN losses in Experiment 1 were not taken for the last week due to problems with background measurement.*

Table 2. N lost to volatilisation as a proportion of N applied in fertiliser (% N) at Walpeup and Longerenong.

Location	Treatment	N loss (%)	Period of loss
Walpeup	46U	4.7	20 Aug – 4 Sep
	GU	1.0	20 Aug – 28 Aug*
	UAN	1.3	20 Aug – 28 Aug*
Longerenong Experiment 1	92U	19	3 Sept – 23 Sept
	46U	26	3 Sept – 23 Sept
	AS	12	3 Sept – 19 Sept**
	UAN	12	3 Sept – 19 Sept**
Longerenong Experiment 2	92U	16	10 Sept – 30 Sept
	46U	13	
	AS	2.8	

** Shorter period of measurement due to storm damage to samplers.*

*** Shorter period of measurement due to problem with the background measurement.*

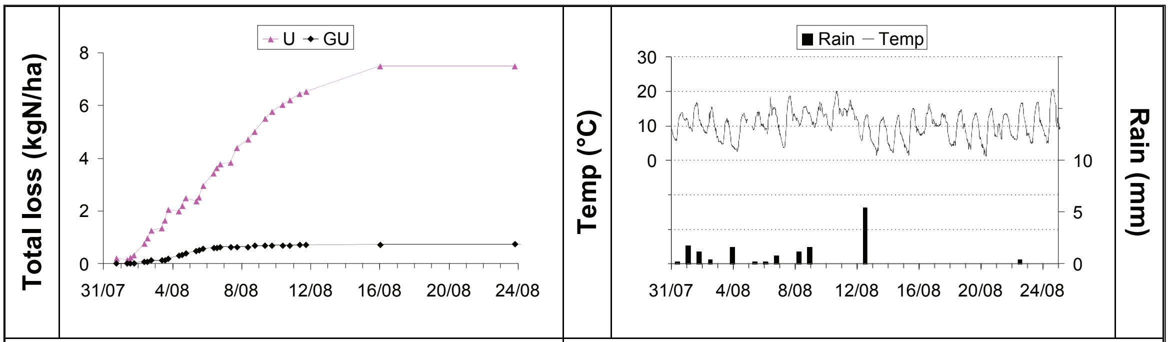
Interpretation

There are two possible explanations for the low volatilisations of ammonia at Walpeup. The first is that due to the soil being sandy and very dry, it is possible that the 4mm of rain that fell on 22 August, two days after fertiliser was applied, was sufficient to wash most of the urea deep enough into the soil to make it safe from volatilisation. The other reason could be that once the urea hydrolysed with the 4mm of rain on 22 August the topsoil dried out very quickly and there was simply insufficient water in the topsoil to allow for significant volatilisation.

Daily rainfall for the twenty days after fertiliser application during the experiments at Longerenong was less than 4mm. These small rainfall events are ideal for promoting volatilisation. The rainfall at Longerenong during Experiment 1 was thought to have been insufficient to wash fertiliser into the soil, hence the higher rates of volatilisation from the 46U and UAN treatments in Experiment 1 compared to Walpeup.

The frequent rainfall events during the first week of Experiment 2 may have been enough to wash some fertiliser into the soil, which might account for the lower volatilisation compared to Experiment 1, despite warmer temperatures during the Experiment 2 measurement period.

The data obtained from the 2008 trials highlights how difficult it is to predict N losses to volatilisation, as the losses differ to results gained in similar experiments in 2007. In 2007, at a Wimmera trial site at Gerang Gerung (on Wimmera clay), N loss to volatilisation was only 9.5 percent of the N applied as urea and one percent of the N applied as Green Urea (Figure 2a). Rainfall events during this experiment were similar to those experienced during Experiments 1 and 2 at Longerenong in 2008, being enough to cause volatilisation, but not enough to wash the fertiliser into the soil (Figure 2b).



(a) Cumulative ammonia loss from urea and Green Urea

(b) Rainfall (mm) at Gerang Gerung, 31 July – 24 August 2007

Figure 2. (a) Cumulative ammonia loss from application after application of 80kg N/ha as granular urea and Green Urea on 31 July 2007 at Gerang Gerung, Wimmera; and (b) accompanying temperature and rainfall for the study period (24 days after fertiliser application).

Alternative N fertilisers to granular urea are often used to avoid volatilisation. Experiment 1 in 2008 at Longerenong has shown that volatilisation losses from liquid UAN can be almost as high as that from granular urea without follow up rainfall (12 percent for UAN, 16 percent for 92U and 23 percent for 46U for the same period, 3 September to 19 Septermber). These figures are very important to our understanding and use of UAN.

Variable results were obtained from the AS treatments in Experiments 1 and 2 with much lower N losses in Experiment 2 (thought to be due to some degree of 'washing in') than Experiment 1 (12 percent compared to 2.8 percent respectively). Losses of N where AS was used in Experiment 1 were slightly lower than losses from urea for a similar measurement period. Generally AS is less susceptible to volatilisation than urea due to the form of N in the fertiliser. Experiment 1 has shown that significant N losses can still occur when AS is applied under adverse conditions (small rainfall events not sufficient to wash the fertiliser into the soil).

Green Urea is coated with agrotain which acts to inhibit the urease enzyme – the enzyme responsible for driving the conversion of urea to ammonia during volatilisation. This inhibitor reduced volatilisation losses from Green Urea compared to urea in 2007, but in this experiment losses were lower than those experienced at Longerenong during 2008 (9.5 percent N lost from urea in 2007 compared to between 13-16 percent in 2008). After the 2007 experiment, it was concluded that losses from urea (under adverse conditions for top-dressing) were not as high as previously thought and it was likely the extra cost for Green Urea could not be justified if the aim is to apply fertiliser before a strong forecast rainfall event. Unfortunately, storm damage at Walpeup makes it difficult to compare losses from Green Urea to urea in the 2008 results, but it appears that they were again lower than losses from urea.

Application

Trial work in 2007 and 2008 has shown that losses of N to volatilisation after application of N fertilisers in-crop can be highly variable when follow up rainfall is not sufficient to wash the fertiliser into the soil.

Commercially, when applying urea in-crop the aim is always to top-dress in front of a strong forecast rainfall event. When the forecast rainfall event does not eventuate or falls are less than expected, this trial work has shown N losses from topdressed urea can be as high as 26 percent.

The 2008 work has shown urea is not the only N fertiliser to be affected by volatilisation. UAN and AS can experience similar volatilisation losses when follow up rainfall is not enough to wash fertiliser into the soil. Neither of these products can provide insurance against volatilisation in the case of an incorrect rainfall forecast.

Green Urea contains a coating to slow down volatilisation, but comes at a price premium to normal granular urea. This product may be useful if the extra cost of the product can be justified by its ability to inhibit volatilisation, potentially allowing large acreages to be top-dressed more than a few days before a forecast rain. However, the best advice for application of N in-crop is always to apply fertilisers before a strong forecast for rain – at least 5-10mm on a sandy loam and 10mm or more on a heavy clay.