Nitrogen Source Effects on Ammonia Volatilization as Measured with Semi-Static Chambers

Claudia Pozzi Jantalia, Ardell D. Halvorson,* Ronald F. Follett, Bruno Jose Rodrigues Alves, Jose Carlos Polidoro, and Segundo Urquiaga

ABSTRACT

Ammonia (NH₃) volatilization is one of the main pathways of N loss from agricultural cropping systems. This study evaluated the NH₃–N loss from four urea-based N sources (urea, urea-ammonium nitrate [UAN], SuperU, and ESN [polymer-coated urea]) surface band applied at a rate of 200 kg N ha⁻¹ to irrigated, strip-till corn production systems for 2 yr using semi-static chambers (semi-open and open) to measure NH₃–N loss. The efficiency of the semi-static chambers in estimating NH₃–N loss under field conditions was determined using ¹⁵N labeled urea applied at rates of 50, 100, and 200 kg N ha⁻¹. Both chamber types had similar NH₃–N recoveries and calibration factors. Immediate irrigation with 16 to 19 mm of water 1 d after N fertilization probably limited NH₃–N volatilization from surface-applied N fertilizers to a range of 0.1 to 4.0% of total N applied. SuperU, which contains a urease inhibitor, had the lowest level of NH₃–N loss when compared to the other N sources. Analyzed across years, estimated NH₃–N losses for the N sources were in the order: ESN = UAN > urea > SuperU. Both years the results showed that measurement time may need to be increased to evaluate NH₃–N volatilization from polymer-coated urea N sources such as ESN. The open-chamber method was a viable, low cost method for estimating NH₃–N loss from small field plot N studies.

NITROGEN FERTILIZER CONSUMPTION has increased more rapidly than that of P or K to support world food supplies (FAO, 2006). Improperly managed, N fertilizers can form gaseous or soluble compounds with potential to pollute air (NH₃, NOₓ, N₂O) or contaminate surface and ground waters with nitrate N (Aneja et al., 2003). Ammonia is the most reduced form of reactive N in the atmosphere and is increasing from human activities (Aneja et al., 2008) with an unpredictable fate of when and where it will be redeposited into the global N cycle (Galloway et al., 2004). Agriculture represents 20 to 80% of NH₃–N emissions in many countries with livestock manures and N fertilizers as major sources (Misselbrook et al., 2000; Anegia et al., 2008; Zhang et al., 2010).

Ammonia volatilization is one of the main pathways that N is lost from organic and inorganic N fertilizer application (Ma et al., 2010). This can result in low nitrogen use efficiencies (NUE) by crops (Bouwman et al., 2002; Rickette et al., 2008). The amount of NH₃ volatilized from surface-applied N fertilizer is controlled by many interacting soil characteristics and climatic factors and is difficult to predict (McGinn and Janzen, 1998). Over the past 35 to 40 yr, development of methodology to measure NH₃ losses under field condition has led to an improved understanding of major factors that drive this loss under dynamic field conditions (McGinn and Janzen, 1998, Misselbrook and Hansen, 2001). Conditions that favor gaseous loss of NH₃ from surface-applied N includes high crop residue, warm temperature (>13°C), a drying soil surface (water vapor loss from surface), neutral or alkaline soil pH, and low cation exchange capacity (as found in sandy soil) (Clay et al., 1990; Ferguson and Kissel, 1986; Bouwmeester et al., 1985; Sommer and Christensen, 1992).

Advances in N management and fertilizer technology have made it possible to reduce NH₃–N losses (Snyder, 2008). Enhanced-efficiency N fertilizers that control N release have been available in the U.S. fertilizer market for several years, but their use has been limited due to their higher cost (Stewart, 2008). However, increasing N fertilizer prices, heightened environmental awareness, increasing area under conservation tillage agriculture and improved manufacturing technology has led to increased interest in enhanced-efficiency N fertilizers (Rickette et al., 2009; Halvorson et al., 2010).

Different techniques have been employed to measure NH₃ loss from N sources applied to soils (Misselbrook et al., 2005; McGinn and Janzen, 1998; Cabrera et al., 2001; Pacholski et al., 2006). Most of these measurement techniques represent major categories: micrometeorological, enclosure, and indirect methods. The micrometeorological (direct) and ¹⁵N balance (indirect) methods (McGinn and Janzen, 1998) allow absolute estimates of NH₃–N loss in the field because they do not interfere with atmospheric conditions near the soil surface or affect NH₃ volatilization.

Evaluating the effects of N source, N application rate, or soil management on NH₃ emissions in field environments generally requires several treatments and replications, and small plots (<50 m²) where the fetch criterion is not adequate to...