Maize (Zea mays L.) is one of the most important crops in China, and its cultivation increased rapidly in the last decades. High doses of nitrogen (N) fertilizers are widely applied for high grain yield. Quantifying the fates of fertilizer N, especially the use efficiency by aboveground biomass (NUE) and their losses to the environment and the atmosphere, is critical for local agricultural management. However, up to now, it is not clear on fate of N fertilizer and how and how much the applied nitrogen is lost, particularly by the various forms of gaseous N.

We have conducted six new $^{15}$N tracer experiments and combined previous results to evaluate the fates of N fertilizer in maize cropping systems across China. In order to accuracy evaluate the gaseous N loss, a fully automated measuring system was built to simultaneously measure soil N$_2$O and NO emissions in 2017 and 2018 for a typical maize field in Northeast China; to identify the source (soil N or fertilizer N) of gases of NO, N$_2$O and NH$_3$, another field experiment was conducted in the adjacent field using $^{15}$N-labeled fertilizer.

We found that, on average, 34%, 35% and 31% of the applied N fertilizer (averagely 222 kg N ha$^{-1}$, n = 23) was taken up by crop, retained in the soil and lost to the environment, respectively. The results of the automated measuring system showed that the release rates of NO and N$_2$O were 9.1 and 2.6 kg N ha$^{-1}$ in 2017, 2.6 and 2.2 kg N ha$^{-1}$ in 2018, respectively. Relatively high NO emission rate in 2017 might be caused by relatively low annual precipitation in that year (437 mm in 2017 and 581 mm in 2018). The results of the static chamber system showed that the release rates of NH$_3$, NO and N$_2$O during the maize growing period were only 1.6, 1.8 and 1.4 kg N ha$^{-1}$, respectively, while NO and N$_2$O emission using this method being much lower compared to the auto system with high resolution. $^{15}$N labeling experiment showed that 67%, 52% and 29% of the released NH$_3$, NO and N$_2$O came from the applied fertilizer N. Seasonal patterns of soil NO and N$_2$O emissions were similar, indicating they were controlled by similar factors. Among the factors, soil temperature and moisture were significantly related to the emissions of NO and N$_2$O, and soil temperature was significantly controlling the NO/N$_2$O ratio in this study site.

**Key words:** nitrogenous gases losses, maize crop, nitrogen fertilization, $^{15}$N trace, nitrogen use efficiency (NUE)