http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 8 (3): 429-432, 2005
ISSN 1028-8880

Measurement of Ammonia Emission Following Surface Application of Urea Fertilizer from Paddy Fields

Md. Toufiq Iqbal
Department of Agronomy and Agricultural Extension,
University of Rajshahi, Bangladesh

Abstract: Ammonia emission from agriculture is one of the most important pathways of nitrogen loss from agricultural cultivated field. In this study, the measurement of ammonia emission from paddy field obtained by surface application of urea fertilizer was reported. The main objective of the present study were to assess amount of NH_3 emission and the loss of nitrogen from paddy field as affected by various N doses, i.e. 0 (control), 90 (N_1), 180 (N_2), 270 (N_3) and 360 (N_4) Kg ha^{-1}, following field surface application of urea fertilizer. Ammonia emissions were measured by continuous air flow enclosure method from plots fertilized with the application of surface urea. Increase in urea-N dosage increased NH_3 emission that was measured from paddy field. Most of the NH_3 emission occurred during the first 12 days after fertilizer application. Highest ammonia emission rate was 28 g day^{-1} and total amount of ammonia emission was 56.21 kg ha^{-1} in N_4 treatment. The results also show that N loss through NH_3 emission accounted for 11 to 16% during the rice growing season. These magnitudes of loss of N appear to be most important for environmental point of view.

Key words: Ammonia emission, surface application, urea, paddy field, nitrogen loss

INTRODUCTION

Ammonia emissions to the atmosphere are considered a threat for environment in the world. It is one of the main pathways of nitrogen loss from soils. The proportion of N lost by emission measured using the micrometeorological method ranged from 0 to 60% under various conditions[1,2]. Urea-based fertilizers are commonly used in paddy field because they are highly concentrated, relatively less leaching occurs compared with nitrate fertilizer forms and they are less toxic to man and animals than nitrate-containing N fertilizers[3,4]. Urea fertilizer has been shown to produce the highest emissions of the total available NH_3 at 6-25%.When urea fertilizer is added to soil, it is usually hydrolyzed to ammonium carbonate by soil urease[5]. Harper *et al.*[6] showed large losses of NH_3 from the soil surface following surface application of N. Harper *et al.*[7] demonstrated large losses from plant canopies (via the stomata) due to an excess of soil N in relation to plant needs. Other work has shown significant NH_3 absorption from atmosphere due to plant N stress and/or high atmospheric NH_3 concentrations[8]. Values of ammonia emission factors from fertilizers are typically expressed as a percentage of nitrogen applied that volatilizes as ammonia. Several authors have reported empirical ammonia emission rates as functions of wind speed, soil pH and soil moisture content[9]. In many regions the release of NH_3 has increased in recent years and re-deposited NH_3 may play an important role in soil acidification[10]. However, very little work has been carried out to determine ammonia emissions and nitrogen loss from paddy field through surface application of urea fertilizer. The present study was undertaken to estimate gaseous loss of applied N through NH_3 emission in paddy field. The specific objective was to measure the degree of NH_3 emission from paddy field as affected by urea-N dosages.

MATERIALS AND METHODS

The experimental sites: The experimental paddy field is located in ShuangQiao farm of Zhejiang University at northern part of Zhejiang Province (120°40'E, 30° 50'N), in southeast coastal area of china. This region possessed the characteristics of typical climate, terrace and agriculture practice of the coastal area. The annual precipitation of the area was 1205.5 mm, of which 1006.7 mm occurred from April to August. The soil is coastal saline clay loam and blue soil with medium fertility. The soil in the plot trail contains 0.06-0.08% total N, 0.05-0.06% total P, 1.2-1.4% organic matter, 0.1-0.3% total salt, pH 7.6-7.8. The mean air temperature during the experimental period was 28.1°C and the average maximum temperature was 34°C.

Experimental design: The experiment was designed to represent fertilizer application to paddy field. Urea was broadcast evenly by hand in each 4x5 m size plots. The

Table 1: Nitrogen fertilizer treatment

Nitrogen treatment	Urea (kg ha^{-1})	Pure nitrogen (kg ha^{-1})
N_0	0	0
N_1	196	90
N_2	392	180
N_3	588	270
N_4	784	360

experimental field consists of 15 plots and a strip of 0.3 m land was left between the plots. The experiment was laid down in a Completely Randomized Block Design with three replicate. Sixty percent of the total amount of urea-N was applied as a basal dressing and 40% was top-dressed in rice growing season. Each plot received same fertilizer treatment throughout the experiment, which were incorporated in the plough layer before flooding (Table 1). The rice seedlings were transplanted the current day when basal fertilizer was applied. All fields were plowed with a tractor and harrowed three times in a dry condition to about 15 cm depth.

Measurements of ammonia emission: Ammonia emission rate was measured using a continuous air flow enclosure method[11]. The chamber volume of the volatilization chamber (200 mm in diameter) can be adjusted with the chamber depth inserted into soil/water. The rate of airflow, generated by a pump, was adjusted using valves to 15-20 times the chamber volume per minute[12]. Two control chambers were put into a basin with irrigation water.

Ammonia emission rate was measured twice a day, in the morning and in the afternoon after urea application. The air was continuously pumped for 2 h and allowed to flow through NH_3 absorbent (2% H_3BO_3) for each measurement. After measurement, chambers were moved away to avoid any effects of the chambers on environmental conditions. The measurement was continued every day until there were no significant differences between the NH_3 volatilization rates from the N treatments and the control (no N addition). Daily NH_3 emission was calculated by the average of the rates measured on each day. Total NH_3 emission was calculated by the sum of the daily emission rates over the period. Air temperature was recorded when NH_3 emission was measured.

RESULTS

Ammonia emission: Figure 1 showed relationship among ammonia emission, period of sampling, nitrogen fertilizer treatment and temperature from paddy field. Background emissions were very low for the first 2 day prior to the fertilizer application, but immediately following the application, NH_3 emission increased significantly. The NH_3 emission rate reached its maximum 2-3 days after urea was applied to the paddy field and then decreased

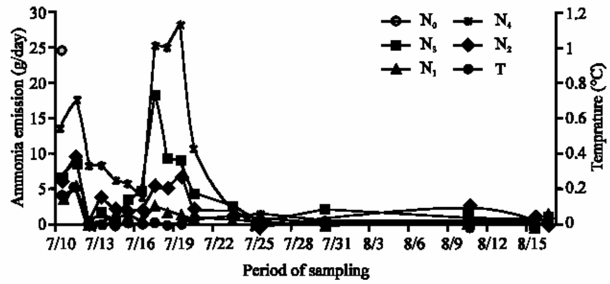

Fig. 1: Relationship among temperature, nitrogen fertilizer treatment for ammonia emission

Table 2: Total ammonia emission from N fertilizer application

	NH_3 emission	
Nitrogen treatments	Amount (kg ha^{-1})	Nitrogen loss percentage
N_0	7.08	-
N_1	11.97	13.30
N_2	22.68	12.60
N_3	30.20	11.18
N_4	56.21	15.61

gradually to a level similar to the control. Large ammonia emission were measured in 19th July. At the end of 12 day NH_3 emission were drastically decreased (near to zero) in all treatments. Ammonia emission started immediately and was almost complete within 12 days after urea application to the soils. Ammonia emissions were nearly constant in all treatments from 12 days after fertilizer application. During sampling of ammonia emission temperature varied from 23 to 33°C. So, it was mentioned that ammonia was not remarkably emitted in the day of maximum temperature. From this Fig. 1 it was clearly justified that ammonia emission rate was increased with the increasing rate of nitrogen fertilizer application. Temperature was the not prominent factor for ammonia emission. There were no considerable ammonia emissions after 22nd July in all treatments. Some times no emission. Ammonia was emitted just after fertilizer application. Maximum ammonia emission was 28 g day^{-1} in N_4 treatment that was just 9 days after fertilization. Present results show that NH_3 emission was a rapid process that was completed within 12 days after N application. After this period there was no significant increase in periodic or cumulative NH_3 loss.

Amount of ammonia emission and nitrogen loss percentage: In Table 2, total ammonia emission was estimated in the period of 10th July to 13th August in each treatment separately. There was linear relationship between amount of ammonia emission and nitrogen treatment. Amount of NH_3 emissions in N_0, N_1, N_2, N_3, N_4 and N_5 were 7.08, 11.97, 22.68, 30.20 and 56.21 kg ha^{-1}, respectively. But for the case nitrogen loss through NH_3 emission, nitrogen loss percentage was fluctuating with respect to nitrogen fertilizer treatment. Losses of nitrogen (expressed as a percentage of that applied), following N_1, N_2, N_3, N_4 treatments were 13.29, 12.59, 11.18 and 15.61 respectively. However, the losses measured from the paddy field increased from about 11 to 16% of the N applied when the application rate was increased from 0 to 360 kg N ha^{-1}.

DISCUSSION

The application of urea in the paddy field resulted in significant ammonia emissions and nitrogen losses. The extent of these losses was affected by the soil conditions and atmosphere.

Ammonia emission: Ammonia emission was a rapid process that was completed in 6-9 days after fertilizer application. Same opinion was observed from other researchers. Ammonia gas has a relatively short lifetime in the atmosphere of a few hours to a few days[13]. In contrast, the ammonium ion, as an aerosol, may have a lifetime on the order of 1-15 days[14]. Present results indicate that the amount of NH_3 emission in 6 days (16 to 22nd July) accounted for more than 90% of the total ammonia emitted. The results indicate that NH_3 emission was faster during the paddy growing period. The temperature during the rice growth period was higher which might be the main reason leading to faster hydrolysis of urea and driving NH_3 emission[15].

Amount of ammonia emission and nitrogen loss percentage: The amount of NH_3 emission increased with the increase in urea-N dosage. There was also a trend of increasing amount of NH_3 percentage that was emitted with higher doses of urea. The results, concerning the increase in NH_3 losses in relation to N dosage, are in agreement with those reported by Nelson[16]. However, Nelson's results showed that the proportion of added N that was emitted as NH_3 remains constant across the range of N application. Net cumulative NH_3 emission losses during sampling period were 11 to 16% for the applied fertilizer throughout the experiment. This finding is consistent with those of other workers, whose field experiments have shown emissions ranging from 6 to 49% of the applied urea-N[17-20]. A similar relationship was also noted by Black *et al.*[21], who observed an increase in NH_3 loss from 13 to 33% of the N applied as the application rate increased from 30 to 200 kg N ha^{-1}.

This experiment was conducted under field conditions in order to provide a preliminary measurement of potential NH_3 emission from surface applied urea fertilizer on paddy field. Surface application of urea-based fertilizers may result in loss of some N by emission of NH_3. Losses of NH_3 from fertilized plots were higher as compared to control. Increase in urea-N dosage increased NH_3 emission from the field. The loss of ammonia by emission after fertilizer application may lead to large losses of soil-plant nitrogen. Ammonia emissions are basically determined by the amount of nitrogen excreted in the urea. Therefore the total amounts of NH_3 emissions were 56.21 kg ha^{-1} and maximum nitrogen loss through NH_3 emission was 16%, respectively. A loss of this magnitude would important, especially in view of the possibility that when urea will be emitted, ammonia reacts with oxides of nitrogen and sulfur to form particles, typically in the fine particle size which will be deposited in the ecosystem. So, ammonia emission from the field causes environmental problems and losses of a valuable fertilizer resource.

ACKNOWLEDGEMENTS

Md. Toufiq Iqbal is thankful to UNESCO and China Scholarship Council (CSC) for financial assistance under UNESCO and the China Great Wall fellowship programme. Also, the author is wishing to express his gratitude to the 'National Natural Science Foundation of China' (Grant No.2002CB410807) for subsiding this research.

REFERENCES

1. Chen, R.Y. and Z.L. Zhu, 1982. Studies on the fate of nitrogen fertilizer 1. The fate of fertilizer in paddy soils. Acta Pedologica Sinica, 19: 122-129 (in Chinese).
2. Khanif, G.J.D. and P.H. Nye, 1992. A model of ammonia volatilization from application urea: The effects of steady-state drainage and evaporation. J. Soil Sci., 42: 103-113.
3. Nommik, H., 1973a. The effect of pellet on the ammonia loss from urea applied to forest soil. Plant Soil, 39: 309-318.
4. Nommik, H., 1973b. Assessment of volatilization loss of ammonia from surface applied urea on forest soil by ^{15}N recovery. Plant Soil, 38: 589-603.
5. ECETOC (European Centre for Ecotoxicology and Toxicology of Chemicals), 1994. Ammonia emissions to air in western Europe. Technical Report No. 62. Brussels, pp: 196.
6. Harper, L.A., V.R. Catchpoole, R. Davis and K.L. Weier, 1983. Ammonia volatilization: Soil, plant and microclimate effects on diurnal and seasonal fluctuations. Agron. J., 75: 212-218.

7. Harper, L.A., R.R. Sharpe, G.W. Langdale and J.E. Giddens, 1987. Nitrogen cycling in a wheat crop: Soil, plant and aerial nitrogen transport. Agron. J., 79: 965-973.
8. Harper, L.A. and R.R. Sharpe, 1995. Nitrogen dynamics in irrigated corn: Soil-plant nitrogen and atmospheric ammonia transport. Agron. J., 87: 669-675.
9. Whitehead, D.C. and N. Raistrick, 1990. Ammonia volatilization from five nitrogen compounds used as fertilizer following surface application to soils. J. Soil Sci., 41: 387-394.
10. Van Breemen, N., P.A. Burrough, E.J. Velthorst, H.F. Van Dobben, T. De Wit., T.B. Ridder and H.F.R. Reijnders, 1982. Soil Acidification from Atmosphereric Ammonium Sulphate in Forest Canopy Throughfull. Warneck, P. (Ed.) Chemistry of the Natural Atmosphere. New York, Academic Press, 1988. pp: 429-515.
11. Kissel, D.E., H.L. Brewer and G.F. Arkin, 1977. Design and test of a field sampler for ammonia volatilization. Soil Sci. Soc. Am. J., 41: 1133-1138.
12. Liao, X.L., 1983. Method of nitrogen gas loss research. Prog. Soil Sci., 15: 49-55 (in Chinese).
13. Dentener, F.J. and P.J. Crutzen, 1994. A three-dimensional model of the global ammonia cycle. J. Atmos. Chem., 19: 331-335.
14. Aneja, V.P., J.P. Chauhan and J.T. Walker, 2000. Characterization of atmospheric ammonia emissions from swine waste storage and treatment lagoons. J. Geophys. Res. (Atmospheres); 105: 11535-45.
15. Li, S.Q. and X.S. Li, 1999. Effective factors on urea hydrolysis. Plant Nutr. Fert. Sci., 5: 150-162 (in Chinese).
16. Nelson, D.W., 1982. Gaseous Losses of Nitrogen Other than Through Denitrification. In: Steven, F.J. (Ed.), Nitrogen in Agricultural Soils. Agronoour, 22: 327-364.
17. Black, A.S., R.R. Sherlock, N.P. Smith and K.C. Cameron, 1989. Ammonia volatilization from urea, applied to soil of varying moisture content. J. Soil Sci., 38: 679-687.
18. Black, A.S., R.R. Sherlock and N.P. Smith, 1987. Effect of timing of simulated rainfall on ammonia volatilization from urea, applied to soil of varying moisture content. J. Soil Sci., 38: 679-687.
19. Catchpoole, V.R., D.J. Oxenham and L.A. Happer, 1983. Transformation and recovery of urea applied to a grass pasture in southeastern Queensland. Australia J. Exerp. Agric. Anim. Husb., 23: 80-86.
20. Sommer, S.G. and C. Jensen, 1994. Ammonia volatilization from urea and ammonical fertilizers surface applied to winter wheat and grass land. Fert. Res., 37: 85-92.
21. Black, A.S., R.R. Sherlock, N.P. Smith and K.C. Cameron, 1989. Ammonia volatilization from urea, broadcast in spring on to autumn-sown wheat. N.Z.J. Crop Hortic. Sci.,17: 175-182.