Effects of Synthetic Nitrogen Fertilizer and Compost Chicken Manure on Ammonia (NH_3) Volatilization in Winter Wheat system

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Abstract

The volatilization of ammonia is an important nitrogen (N) loss path in agricultural production, which not only results in a loss of economy, but also represents a significant atmospheric pollutant. Volatized ammonia (NH_3) from livestock manure and cropping field is associated with ecosystem and public health and can also be an indirect source of greenhouse gases. The rate of ammonia volatilization after application of fertilizers is strongly affected by many factors such as soil properties, temperature as well as the type, application time and mode of nitrogen fertilizers. This work aimed to quantify the losses of N by volatilization of ammonia from synthetic nitrogen fertilizer and composted chicken fertilizer in the volatilization of ammonia (NH_3) in winter wheat system by the calibrated Dräger-Tube method. An experiment of four treatments Control (CK), Farmer's compound fertilizer-NPK (CF), Chicken manure compost (25%) + Urea (75%) (MF) and Chicken manure compost (CM) was conducted, with wheat culture in Baizhai County, Quzhou County, Hebei province, following a delineation of casualized blocks, with three repetitions. The daily variation of the ammonia volatilization flow was not dramatically influenced by the type of fertilizer and its combination, ranging from 0.01 to 0.23 mg N m^{-2} h^{-1} in base fertilization and 0.03 to 0.44 mg N m^{-2} h^{-1} in topdressing fertilization. The results showed that the cumulative losses of volatilization of NH_3 were significantly affected ($P \leq 0.05$) by the type of fertilizer and its combination. The cumulative volatilization losses of NH_3 in the treatments CM, CF, MF were 14.30 kg N/ha, 21.58 kg N/ha and 25.79 kg N/ha corresponding to 5.72 %, 8.63%, 10.32 % of the total application rates of N, respectively. Emissions factors of Ammonia were highly variable depending on the type of fertilizer or combination of fertilizer. The results showed that wheat yield has been substantially improved by the application of fertilizers alongside organic fertilizers, with the maximum yield achieved in the combination of synthetic and organic fertilizer of about 10.79 t/ha, whereas the isolated organic and synthetic fertilizer (NPK) was not significantly different at around 10.3 t/ha and 10.4 t/ha respectively. Synthetic and organic fertilizers combined proportions with chemical fertilizers have significantly different performance in the volatilization of ammonia, emissions factors and crop yields. Chicken manure can be applied alone or in combination with 75% chemical nitrogen (urea) to achieve the yield of the similar crop or more as with chemical fertilizer alone, and thus reducing the excessive use of chemical fertilizer and the gaseous loss of nitrogen fertilizer, thus being economically beneficial and environmentally sound.

Keywords: Manure; Synthetic fertilizer; Winter wheat; Yield; Ammonia

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1. Introduction

Nitrogen (N) is the nutrient most required by cultures, exceeding potassium, and phosphorus in quantity (Raij, 1991). The element represents 78% of the gases in the atmosphere; however, despite this abundance, there is a shortage of this nutrient in an available form for plants, which can be explained by the extraordinary stability of N_2, which unlike other diatomic molecules. According to Fancelli (2000) to produce 1 ton of grains per hectare of corn are absorbed from 18 to 20 kg of nitrogen by the plant of which 15 kg migrate to the grain, therefore exported from the area. The global 'Green revolution' of the late 1950s and early 1960s generated unprecedented growth in food production; however, these achievements have come at some cost to the environment (Grierson et al., 2011;

Sutton et al., 2011). For example, during the last three decades, the use of mineral nitrogen (N) fertilizer has more than doubled in China for food security (Liu et al., 2013) while overuse of N fertilizer is also causing numerous environmental problems (Cui et al., 2013; Guo et al., 2020).

Ammonia (NH_3) is a naturally occurring and manufactured colorless gas. The main source of ammonia pollution is agriculture, where it is released from manure and slurry and through the application of fertilizers. Agriculture accounts for about 50% of all ammonia (NH_3) emissions worldwide (Liang et al., 2017; Liu et al., 2017; Sommer et al., 2004). Although NH_3 is not a greenhouse gas (GHG), its emission to the atmosphere constitutes a nutrient loss and affects air quality due to the fact that it is a precursor of $PM_{2.5}$ (Tian et al., 2015). In the atmosphere, ammonia can bind with other gases, such as sulfur dioxide (SO_2) and nitrogen dioxide (NOx), to form ammonium containing fine particulate matter (PM). These fine PM particles cause health impacts when inhaled. Particulate matter has particularly negative impacts on the cardiovascular system and respiratory health, contributing to several chronic conditions such as heart attacks, cerebrovascular disease, chronic obstructive pulmonary disease, asthma, and lung cancer.

Ammonia is a pollutant that can have significant effects on both human health and the natural environment. The impacts of ammonia on biodiversity can be a toxic effect on vegetation or changes in species composition due to nitrogen deposition, which can result in the loss of sensitive species and habitats. Ammonia is just one source of excess nitrogen, along with the nitrogen oxides, NO and NO_2, collectively known as NOx. There are several internationally agreed upon targets to reduce ammonia emissions and its harmful effects, so China has been undertaking several studies to meet these set targets. NH_3 and GHG emissions from soil are influenced by various factors, including crop type, soil properties, climatic conditions, irrigation, fertilization, etc. (Ouyang et al., 2017; Sutton et al., 2008).

2. Research Methodology

2.1. Description of the study area

The Field Experiment was conducted in the village of Gaozhuang, in the village of Baizhai, Quzhou County, in the city of Handan, Hebei province (36.07.3694°N, 114.9611°E) from October 2020 to June 2021 in winter wheat system. The place is at an altitude of 40 m and has a temperate monsoon climate. The soil characteristics of the experimental site before sowing at a depth of (0-30) cm is shown in Table 1 below:

Table 1. Surface characteristics of soils

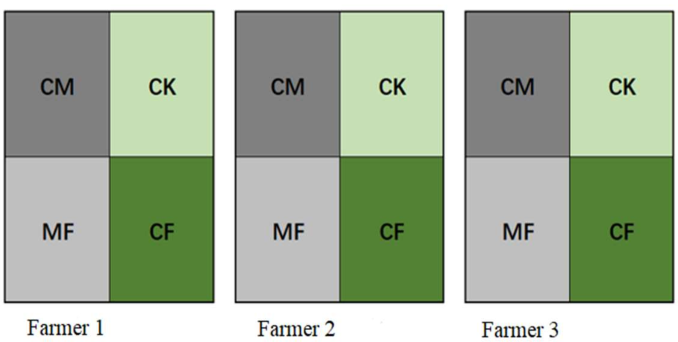
Item	Parameter
SOM (g kg^{-1})	14.43
Total N (g kg^{-1})	0.92
Total P (g kg^{-1})	5.8
Total K(g kg^{-1})	12.3
pH (H_2O)	8.2

2.2. Treatments and experimental design

The field experiment was carried out in a system of rotation of winter wheat and summer corn, typical of the region. We adopted the delineation in casualized blocks with three repetitions with an individual area of 0.41ha, 0.42ha, 0.37ha and used three nitrogen sources that are: Fertilizer compound N-P_2O_5-K_2O (28-5-7) Urea: 46%, and chicken manure and was used a species of wheat (October 2020-June 2021). Synthetic fertilizers and manure were applied uniformly to the soil surface and immediately incorporated into the soil (0-20 cm deep). Detailed information on treatments is given in the Table 2.

Table 2. Experiment design of the winter wheat treatments

Treatments	description	Quantities of fertilizers(kg/ha)
CF	N-P_2O_5-K_2O (28-5-7) (Farmers compound fertilizer)	NPK= 750 N: 750 x 28% =210 P_2O_5: 750 x 5% =37.5 K_2O: 750 x 7% =52.5
MF	Chicken manure compost (25% de replacement) N:2.03%; P_2O_5: 2.24%; K_2O: 1.79%	N: 210 x 25%=52.5 Total: 52.5/2.03%=2586.2 P_2O_5: 2586.2 x 2.24% = 57.9 K_2O: 2586.2 x 1.79=46.3
	Inorganic	Supplement N: 210-52.5=157.5 Urea Total: 157.5/46%=342.5 Supplement K_2O: 52.5-46.3=6.2 Total K_2SO_4: 6.2/52%=11.9
CM	Chicken manure compost	210/2.03%=10344.8
CK	No Nitrogen (Superphosphate $P_2O_5 \geq 16\%$; Potassium Sulfate $K_2O \geq 52\%$)	P_2O_5: 750 x 5% =37.5 Calcium superphosphate: 37.5/16%=234.4 K_2O: 750 x 7% = 52.5 Potassium sulfate: 52.5 /52% = 100.9



Legend

CK: No nitrogen
CF: Traditional fertilization for farmer
CM: Organic fertilizer
MF: Combined application of organic and inorganic fertilizer

Figure 1. A randomized block experimental design.

2.3. Measuring device and procedure

The method for quantifying the volatilization of ammonia after the application of fertilizers presented here was based on the method used by Roelcke, 2000. A Dräger-Tube (DTM) method (Roelcke et al., 2000). The difference in ammonia concentration between indoor air and ambient air is measured without interruption of the near-continuous gas flow. However, unlike time integration methods that produce average emission rates, this method is based on many short-term direct measurements of NH_3 concentrations, resulting in instantaneous values for NH_3 flows.

A Dräger tube has been inserted into the corresponding Dräger gas detector pump (manually operated bellows pump with semi-continuous suction characteristics). An air volume is defined by the number of strokes (1 stroke = 100 cm^3) required for the specific type of Dräger-tube and the measurement range given (usually five to 10 strokes) is drawn through the tube. Ammonia is arrested quantitatively, avoiding problems with handling and analysis of the gas.

The total length of the color change is a measure of the concentration of NH_3, which is read directly from a scale printed on the tube in ppm volume (µl 1) NH_3. Four cups made of aluminum foil serve as gas collectors, covering a total area of 400 cm^2. A polyethylene funnel is installed in each cup. The outputs of all four cups are connected through various pieces of 35 cm Teflon tubes to form a portable and portable unit. During measurements, the upper end of the Dräger tube is connected to the Teflon tube leading to the quadruple of the gas manifolds.

According to the intensity of the volatility process, 2 to 3 measurements were taken per day. For the direct flux calculation process, the flux was averaged for each treatment. The NH3 readings (ppm) given in each Dräger tube were multiplied with an atmospheric pressure correction factor, calculated using formula 1 (Pacholski et al., 2006).

$$\text{Correction factor} = \frac{1013\ [\text{hPa}]}{\text{actual atmospheric pressure [hPa]}} \quad (1)$$

After subtraction of the blank value, the values for the NH_3 concentrations (in vol.-ppm) and the durations of measurement (in s) were converted into NH_3-N fluxes [mg N m^{-2} h^{-1}] as follows:

$$FN_g = \text{air volume} \cdot |\text{conc}| \cdot 10^{-6} \cdot \rho NH_3 \cdot \frac{14}{17} \cdot \frac{10000}{400} \cdot \frac{3600}{\text{time}} \quad (2)$$

Where FNg is the NH_3-N flux in mg N m^{-2} h^{-1}; air volume is the throughput of air during one measurement in l; |conc| is the value of the corrected volume concentration (vol.-ppm) of NH_3; NH_3 is the density of NH_3 in mg l^{-1} (ρNH3 = 696 mg l^{-1}; 25◦C, 1013 hPa); 14/17 is the molecular weight conversion factor of NH_3 to N; 10 000/400 is the area conversion factor from cm^2 to m^2 in m^{-2}, and 3600/time is the time conversion factor from s to h in h^{-1} (time = duration of measurement in seconds).

Emission factor calculations and yield

For the calculation of the emission factor for each treatment the formula displayed in the equation

$$\boldsymbol{EF} = \left(\frac{\text{Cumulative } NH_3\text{flux(kg}NH_3-\text{N)}-\text{control}}{\text{N applied(kg N)}}\right) \times 100 \quad (3)$$

Where EF is emission factor and Cumulative NH_3 flux (kg NH_3-N) is the cumulative emission of NH_3-N for a N source treatment (kg N/ha); N applied (kg N) amount of fertilizer applied

3. Results and discussion

3.1. Base fertilizer

3.1.1. Variations of the NH_3 concentration and flux

The main changes in the NH_3 volatilization flow for base fertilization are shown in Figure 2. These results allow us to evaluate the intensity of NH_3 volatilization on different days and the effect of treatments on the distribution of these losses. It can be observed that nitrogen losses due to ammonia volatilization began on the first day after fertilization observing the same day the peak of 0.13 mg N m^{-2} h^{-1} of MF fertilizer (organic and inorganic manure) and lower flux of 0.03 mg N m^{-2} h^{-1} of CM (organic manure only). These losses later, at first probably, are due to the combination of the high N content and the rapid degradation of manure associated with the high temperatures observed.

The peak was reached on the second day after fertilization, followed by a decrease to a low level of 0.01 mg N m^{-2} h^{-1} on the fifth day, when it was no longer possible to capture ammonia (Fig. 6). The mean peak flow value was observed in MF (Chicken manure compost + inorganic) after basal fertilizer application with 0.23 mg N m^{-2} h^{-1}, and the lowest mean value was for CF with 0.01 mg N m^{-2} h^{-1}, almost the control level. As for CM (Chicken manure compost) presented a low volatilization rate probably because tanned esters are sources of organic materials that tend to show reduced volatilization of ammonia, because nitrogen is found, predominantly bound to organic matter or in the form of nitrate. The high losses of MF (Chicken manure compost + inorganic) are probably due to the combination of the high N (urea) and the rapid degradation of Organic Chicken compost associated with the high observed temperatures, pH, which resulted in high ammonia levels.

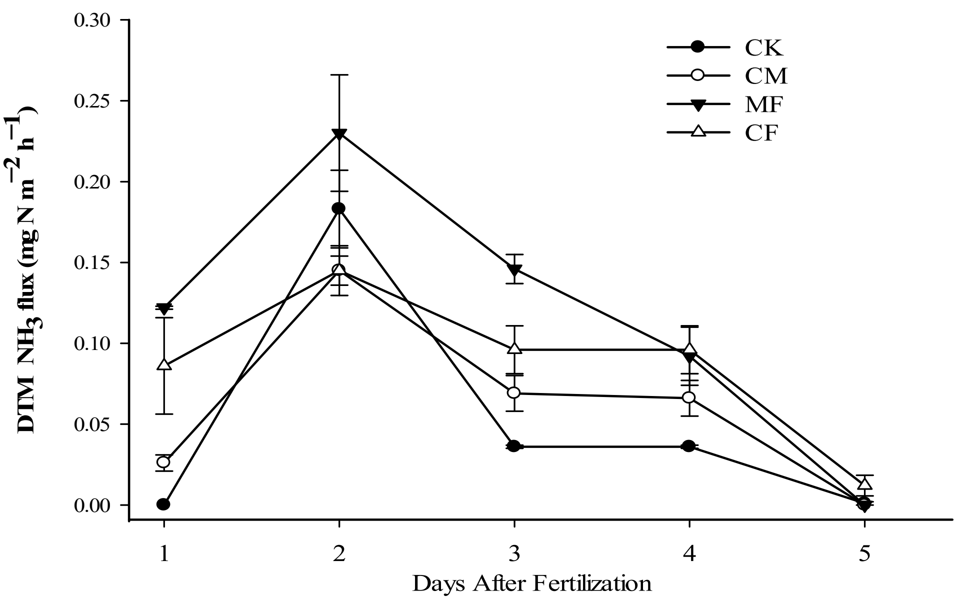


Figure 2. NH_3 fluxes measured by a calibrated Dräger-Tube Method (DTM), following the application of the Control (CK) method, Farmer's compound fertilizer-NPK (CF), Chicken manure compost (25%) + Urea (75%) (MF) and Chicken manure compost (CM) in base fertilizer during the wheat season

It can be inferred that the high relative humidity (70%-85%) and soil moisture content together with them during the measurement period were unfavorable for the NH_3 volatilization. The magnitude of NH_3 losses was largely influenced by small temporal differences in the climate and the initial content of soil moisture. In this study application of fertilizers was with rainy absences, unlike most farmers in China who apply N fertilizer after rainfall. This would increase even more the risk of volatilization of NH_3 because the high humidity of the air or the limited rain provide adequate humidity for the hydrolysis of urea and cause the desorption of ammoniacal N of the sun. In contrast, the strong precipitation effectively attenuates the NH_3 losses by leaching non-hydrated urea in the soil profile where it will be retained. Here, the initial wet conditions of the soil did not favor the rapid hydrolysis of urea and promoted the high initial loss of NH_3. However, this hypothesis would have to be confirmed in future studies, since there are no data available on soil moisture with the application of fertilizers similar to this study**.**

3.1.2. Accumulative flux

Losses due to volatilization of ammonia from nitrogen fertilizers are influenced by several factors such as pH, moisture content, and soil mineral N concentration. According (Sommer et al., 2004), the process of loss by ammonium volatilization represents inefficiency in the management of nitrogen sources applied in the soil, which may result in variable losses between null and greater than 50% of the applied N.

The main significant effects of accumulated NH_3 volatilization flux are presented based on the results of the analysis of variance. For base fertilization, significant effects ($P<0.05$) were observed in the accumulated flux of NH_3 ammonia volatilization (Fig. 3). Therefore, it is observed that the mean values of ammonium accumulated in base fertilization differed statistically. Where for the treatment with CF and MF, they did not differ statistically, with the maximum of 3.9 and 5.4 kg N/ha representing at most 2.8% and 3.9% of the total applied respectively. It is also noted that the total accumulation of nitrogen loss by ammonium volatilization of CF, CM, and control was not significant, with 3.9, 2.8 kg N/ha representing at most and 3.9% 2.0% of the total applied for each treatment respectively.

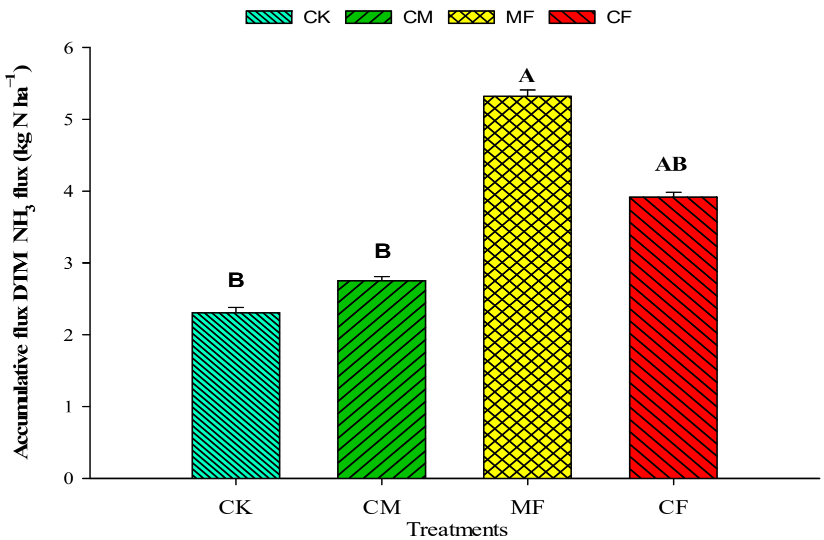


Figure 3. Cumulative NH_3 losses (Unit: kg N ha^{-1}) after application of different fertilizer treatments in base fertilizer during the wheat season. Letter indicates significant difference in $P < 0.05$ between different sources of nitrogen.

In addition, the results obtained in the experiment corroborate the results reported by (Fontoura et al., 2010), which analyzed NH_3-N losses in four consecutive years in the region with similar characteristics and found an average annual loss of NH_3 volatilization of 12.5% of N applied as urea, while in the wettest and driest years respectively, losses ranged from 1.3% to 25.4 % of N applied.

One of the factors that possibly influenced the different losses was air-to-soil temperature, as the lower temperature in the winter wheat growing season may have reduced microbial activity and the hydrolysis of urea fertilizer and compost, also more NH_3 in the gaseous phase and less in the solution phase at a lower temperature 15.23. We can infer that the time and quantity that organic fertilizer (chicken manure) was applied may have influenced N losses by very low volatilization. On the contrary, (Basso et al.,2004) applied chicken manure at different times of the day to identify possible changes in the N volatilization loss pattern but also found that the application time did not consistently affect the N volatilization losses.

3.2. Top dressing

3.2.1. Variations of the NH_3 concentration and flux

The flux of nitrogen loss by ammonium volatilization for all treatments had similar behavior in topdressing fertilization. The main changes in NH_3 volatilization flow are shown in Figure 4. It can be observed that nitrogen losses due to ammonium volatilization began on the first day after topdressing fertilization. The peak daily volatilization flow occurred on the second day, reaching the maximum of 0.44 mg N m^{-2} $h^{-1}$of MF (urea + organic compound), followed by the daily flow of CF with a flow of 0.33 mg N m^{-2} h^{-1} and less flux of 0.25 mg N m^{-2} h^{-1} of CM. On the fifth day, there was precipitation, however, volatilization was considered zero. The lowest mean flow was observed in MF with about 0.03 mg N m^{-2} h^{-1}on the sixth day after fertilization and after rain. This humidity caused a slight rise in the daily flow until the seventh day. Losses at the beginning are likely to be due to the combination of the high N content and the rapid manure degradation associated with the high temperatures observed.

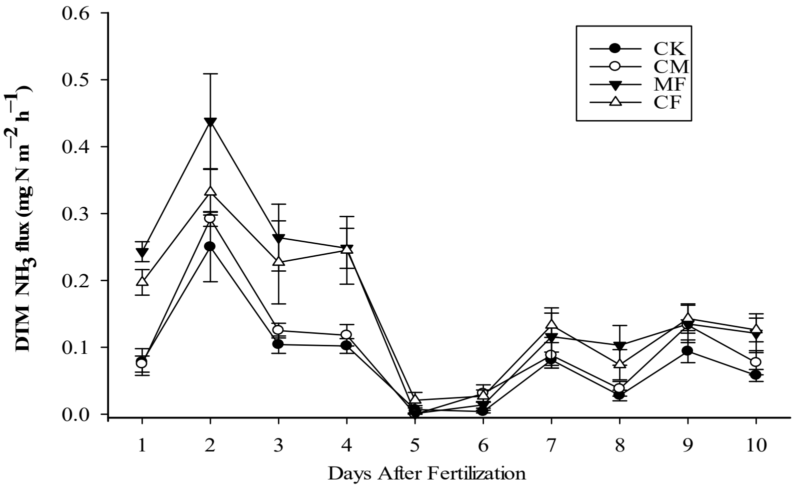


Figure 4. NH_3 fluxes measured by a calibrated Dräger-Tube Method (DTM), following the application of the Control (CK) method, Farmer's compound fertilizer-NPK (CF), Chicken manure compost (25%) + Urea (75%) (MF) and chicken manure compost (CM) in topdressing fertilizer during the wheat season

These data demonstrate that the most significant losses of NH_3 from urea-based fertilizers occur in the first days after application, reinforcing data from other studies with volatilization (Oliveira et al., 2014; Sangoi et al., 2003). Ammonia losses increase with increased pH but decrease with increased cation exchange capacity of solo (Alex Tasca et al., 2011) .

Losses of ammonia are reduced if fertilizers are incorporated into the soil, except for urea. This is because urea must be hydrolyzed before NH_3 is released. The hydrolysis reaction usually depends on the enzyme urease, which is found in organic matter in the soil. For acid soils, irrigation or rain after the application of fertilizers usually reduces NH_3 losses. Again, the situation is a little more complex for urea, because increased soil moisture promotes hydrolysis, which increases NH_3 emissions from urea-based fertilizers. • Ammonia losses are greater when the soil with high moisture content is subjected to "drying conditions", such as the wind or high temperatures. However, in this period it was not possible to discriminate with which factor, temperature, precipitation, pressure, or soil temperature was the most determinant in the volatilization losses of N.

3.2.2. Accumulative flux

The main significant effects of flux of accumulated NH_3 volatilization are presented based on the results of the analysis of variance. For topdressing fertilization, significant effects were observed ($P<0.05$) in the accumulated flux of ammonium volatilization NH_3 (Fig. 5). Where for fertilization of CF and MF, did not differ statistically, with a maximum of 17.6 and 20.5 kg N/ha representing a maximum of 12.3% and 14.3% of the total applied respectively but the treatment with MF was significantly higher than control and CM. The treatment CF and CM did not differ statistically which resulted in accumulated volatilization flow of 11.5 and 17.6 kg N/ha representing about 8.0% and 12.3% respectively and significantly higher compared to the control treatment. Finally, it is also noted that the total accumulation of nitrogen loss by volatilization of ammonia from CM (organic fertilizer) and (CK) control were not significant.

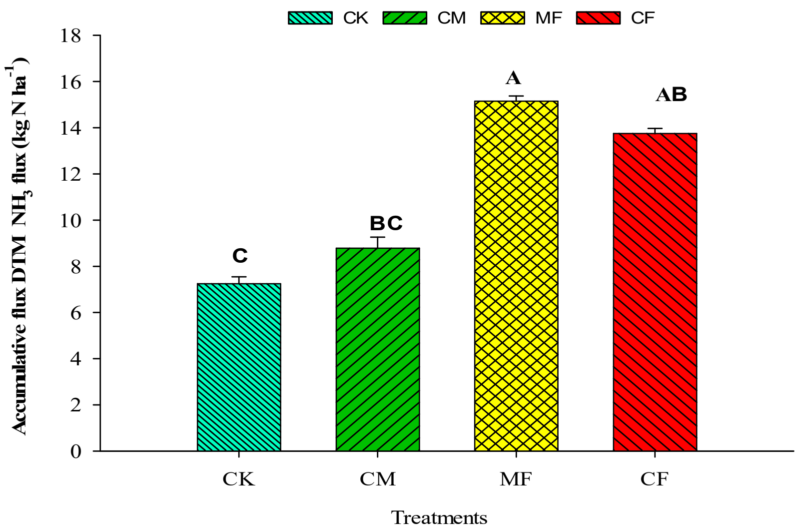


Figure 5. Cumulative NH_3 losses (Unit: kg N ha^{-1}) after application of different fertilizer treatments in topdressing fertilizer during the wheat season. Letter indicates significant difference in $P < 0.05$ between different sources of nitrogen.

Possibly, this difference of cumulative volatilization Flux in the different treatments of nitrogen sources in winter may be related to the level of soil moisture, atmospheric pressure, wind speed in the application of fertilizers (da Ros et al., 2005). In the second application, higher moisture content of the soil may have caused the solubilization of fertilizers immediately after application, while in the first application of fertilizer, the solubilization may have been lower due to the drier soil. Considering the absence of rain in the measurement period, the solubilization of fertilizers may have been influenced by the occurrence of night dew. However, this hypothesis would have to be confirmed in future studies, since there are no data available on soil moisture in the application of fertilizers in this study.

The temperature may have played a preponderant role in ammonia volatilization, as increasing soil temperature increases the solubility of urea or any other nitrogen source, and hence the rate of volatilization of NH_3. Specifically, a Montana, 2016 study revealed that significant losses of NH_3 (almost 40% N applied) of urea applied to the surface can occur even when soil temperatures are cold (<5°F) (Jones et al., 2013). Another study by (Engel et al., 2011) reported that approximately 12% of the applied N was lost within 5 weeks after application, when the soil temperature was 30°F, even when the soil was covered in snow in December. Therefore, soil surfaces may be subject to volatilization losses of NH_3, even if cold or frozen at the time of application of fertilizer N which reinforces the hypothesis of this study.

3.3. Total emissions, emission factor, yield (kg/ha)

Total NH_3 emissions in the autumn experiment showed significant differences ($p < 0.05$) (Table 3). Where it was observed that treatments with synthetic nitrogen in this case CF (farmers compound fertilizer) and MF (urea + organic compound) with 21.58 kg N ha^{-1} and 25.79 kg N ha^{-1} respectively did not differ significantly ($p < 0.05$). But treatments with synthetic nitrogen showed significant differences between organic treatment MF (chicken fertilizer) and control. There were no significant differences between MF and control ($p < 0.05$) for total ammonium emissions with about 14.3 and 11 kg N ha^{-1} respectively.

Table 3. Summary of total NH_3 losses as determined by Drager-Tube, emission factor and yield during field experiments in Baizhai Village, Quzhou County.

Treatments	Total Ammonia loss kg/ha	Emission factor (%)	Wheat yield (kg/ha)
CK	11.85 b	---	8,695 b
CM	14.30 b	6.81	10,318 a
MF	25.79 a	12.28	10,788 a
CF	21.58 a	10.26	10,366 a

Note: Letter indicates significant difference in $P < 0.05$ between different sources of nitrogen

The highest losses due to ammonia volatilization were obtained in the treatment with the application of urea mixed with chicken manure with values up to 25.79 kg/ha of applied N. Higher values have already been obtained by (Lara Cabezas and Korndorfer, 1997) in a study that evaluated the application of urea in the dose of 100 kg N ha^{-1} in no-till and conventional systems, with losses found between 10 and 76% of the N applied in the form of NH_3. But few studies were done with urea mixed chicken manure. Our study confirms that conventional urea fertilizer has a high potential for loss of NH_3 during winter wheat production, similar to previous results in NH_3 volatilization of urea applied to winter wheat using micrometeorological methods (Gericke et al., 2011; White et al., 2002). A wind tunnel experiment conducted by Su et al. (2007) in northern China indicated that NH_3 volatilization losses were 20%-42% for urea-N top dressing during the winter wheat phase.

The response of wheat yield to the application of N was affected by the different sources of N (Table 1). On average, in both synthetic and organic N sources, wheat yield increased significantly by 24.1% (10788 kg/ha) for MF, by 19.2% (10318 kg/ha), and for treatment with CF (organic source) by 18.7% (10366 kg/ha). Between the treatments with CM and CF, the difference in the effect of the nitrogen source was not very expressive or there was practically no expressive increase in production. The rather insignificant effect of N fertilization with the organic source about yield control may be related to the high availability of N in the soil, due to the high content of soil organic matter. This high availability of N resulted in a low yield increase with N fertilization. Possibly, fertilization at rates of 150 kg ha^{-1} N for wheat led to a surplus of N over crop demand, resulting in no difference in the yield between the sources of N.

The results of CF and CK can be attributed to the greater mineralization and supply of nutrients by the residues in the period before planting, due to their composition and greater ease of decomposition by the lowest C/N ratio. In addition, good soil humidity, climate, and good rainfall distribution over the cycle favor the mobility of N towards the roots by mass flow, making the plant less dependent on external sources of N.

Crop yields responded to manure application positively when compared to control. Luo et al. (2018) also reported that organic applications with high N content and low C: N ratio could mineralize enough N to satisfy the plant's growth demands. Poultry manure has a low C: N ratio, high N concentration (Mubarak et al., 2010), and high levels of ammonia (NH_4^+) and nitrate (NO^{-3}) (Wang et al., 2004; Bernal et al., 2009.) and could be recommended to farmers for soil modification (Ren et al., 2019). Manure application significantly increased yield when compared to control, but the junction with inorganic fertilizer did not significantly increase the yield by only less than 1.0%. Both fertilizer and organic fertilizer play a key role in increasing crop yields Fertilizer supplies almost exclusively mineral nutrients that can be directly absorbed by plants; the organic fertilizer provides only a small proportion of the mineral nutrients that can be directly absorbed by the crops, and most nutrients need to be released slowly with the mineralization of organic fertilizers The effects of different types of organic fertilizers on crop yields vary from mineral nutrient content to mineral nutrient content in the soil.

3.4. Soil N before sowing/after harvest

The mineral N in the soil before the cover fertilization showed good availability of N in all treatments (Fig. 6). The highest availability of N in the soil before the application of fertilizers was for MF with approximately 1359 mg/kg and the lowest was for control with approximately 1010 mg/kg. Although there was a small difference of N in the soil, the control was not statistically different with CF, MF, and CM. This condition, reinforced by the high yields obtained in the control treatment, demonstrates that the sowing fertilization and mineralization of soil organic matter were able to supply the N demand for the wheat culture. The preparation of the correct soil of soil and the revolving of the remains of the previous culture favored the rapid mineralization of the light fraction of organic matter that is easily decomposed. After harvesting the wheat, they showed a non-significant mineral N increase in the soil, with the largest increase for the MF with approximately 1844 mg/kg and the smallest was for the MF with approximately 1591 mg/kg.

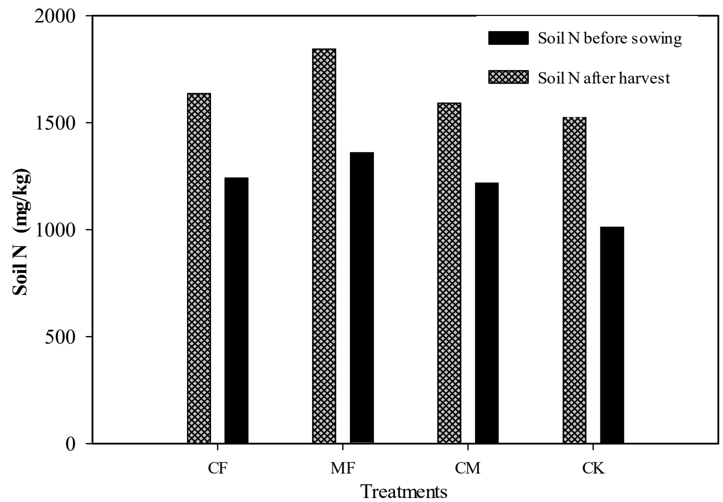


Figure 6. Soil N before sowing/after harvest

This experiment indicated that manure had a similar yield in wheat crop compared to mineral fertilizer, regardless of the specific conditions of the site. This suggests that crop yields can be greatly improved by manure application and more importantly, serve as a substitute for mineral fertilizers. The use of mineral fertilizers cannot be sustained due to high environmental pollution (Liu et al., 2013; Zhang et al., 2015), and in 2015, the Chinese Ministry of Agriculture and Rural Affairs (MARA) announced the zero increase action plan to reduce the use of mineral fertilizers (Liu et al., 2015).

Manure contains abundant nutrients and bonding agents that increase soil fertility and enzymatic activities and improve soil structure (Wang et al., 2017). In our study, manure application did not significantly increase the availability of N in the soil. Manure application should therefore be promoted as a national strategy in China. The current use of manure is relatively low due to transportation difficulties and dissemination problems, but the government could provide subsidies to farmers to promote the use of manure, which would turn the waste into treasures, would increase crop yields, and reduce negative environmental effects. The main practical difficulty is to teach farmers how to use manure.

Crop yields, environmental degradation, and climate change are the main issues affecting agricultural systems and sustainable management strategies are needed to meet future food production needs (Reay et al., 2012).

4. Conclusion

Synthetic and organic fertilizers in proportions combined with chemical fertilizers have significantly different performances in the volatilization of ammonia, emissions factors, and wheat yields. the single application of chicken manure did not have the same effect as the single application of chemical fertilizer. The proportion of chicken manure to urea and the application of conventional chemical fertilizer had no significant effect on wheat yield. Chicken manure may be applied alone or in combination with 75% chemical nitrogen (urea) to obtain the yield of the similar crop or more than only with chemical fertilizers, thus reducing the excessive use of chemical fertilizers and the gaseous loss of nitrogen fertilizers, thus being economically beneficial and environmentally sound.

5. Conflict of interest

We declare that there is no existing conflict of interest between the authors nor institutions mentioned.

6. Acknowledgements

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7. References

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