NITROUS OXIDE EMISSIONS FROM SEVERAL NITROGEN SOURCES APPLIED TO A STRIP-TILLED CORN FIELD[1]

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ABSTRACT

We evaluated the effects of nitrogen (N) source on nitrous oxide (N_2O) emissions from a clay loam soil that was in strip-tilled (ST), irrigated continuous corn production in 2010 near Fort Collins, CO. Emissions were monitored from six different inorganic N fertilizer sources (urea, ESN[1], SuperU, UAN, UAN+AgrotainPlus, UAN+Nfusion). Each N source was applied at a rate of 202 kg N/ha, surface band applied near the corn row and watered into the soil the day after application including a subsurface band application of ESN (ESNssb). A check treatment (no N applied since 2000) located in separate plots and a blank treatment (no N applied) located within the N source plots were included. All treatments except the check were located in plots ST in 2009 that had received 202 kg N/ha of ESN. Nitrous oxide fluxes were measured during the growing season using static, vented chambers for gas sample collection, one to three times per week, and analyzed with a gas chromatograph. With the exception of ESNssb, all N sources had significantly lower growing season N_2O emissions than dry granular urea. Cumulative increases in daily N_2O fluxes were more rapid for urea and UAN than the other N sources following N fertilizer application. The enhanced efficiency fertilizers (polymer-coated, stabilized, and slow release) sources showed potential for reducing N_2O emissions during the 2010 growing season. Corn grain yields in 2010 were not significantly different among N sources, but greater than the blank or check treatments with no N applied. These results indicate that N source selection can be of value in reducing N_2O emissions in irrigated cropping systems under strip-till in the Central Great Plains.

INTRODUCTION

Nitrous oxide is produced in soils through nitrification and denitrification processes (Follett, 2001) with agriculture contributing approximately 67% of the total U.S. N_2O emissions (USEPA, 2010). Nitrous oxide has a global warming potential (GWP) approximately 298 times greater than that of CO_2 (Solomon et al., 2007), thus it is important to develop methods that reduce N_2O emissions in agricultural systems. Nitrogen fertilizer application generally increases N_2O production from irrigated Central Great Plains cropping systems (Mosier et al., 2006, Halvorson et al., 2008).

Available data for analyzing N_2O emissions impact on GWP in irrigated crop production systems is limited (Mosier et al., 2006; Snyder et al., 2009; Archer and Halvorson, 2010). Research

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reported by Mosier et al. (2006) and Halvorson et al., (2008, 2010b,c) from irrigated cropping systems exhibited a sharp rise in N_2O emissions within days following N fertilization with urea-ammonium nitrate (UAN) or urea fertilizers in conventional-till continuous corn (CT-CC), no-till continuous corn (NT-CC), and no-till corn-soybean cropping systems. The N_2O emissions stabilized to near background levels in about 40-45 days following N fertilization and were minimal for the rest of the growing season and non-crop period.

Venterea et al. (2005, 2010) found N source influenced N_2O emissions from corn production systems in Minnesota with greatest N_2O emissions from anhydrous ammonia application, with significantly lower emissions from UAN, and lowest emissions from broadcast urea. Halvorson et al. (2010b) reported reduced N_2O emissions from application of a polymer-coated urea and stabilized N sources when compared to urea in irrigated NT cropping systems. Halvorson et al. (2010c) measured reductions in N_2O emissions as great as 50% using enhanced-efficiency fertilizers compared with dry granular ureas. Hyatt et al. (2010) reported equal potato yields with a single application of polymer-coated urea products compared to 5-6 smaller applications of urea during the growing season, with slightly lower N_2O emissions with the polymer-coated urea products.

Our objective was to determine the effects of N fertilizer source on growing season N_2O emissions from a strip-tilled, irrigated continuous corn production system in 2010.

MATERIALS and METHODS

The study was conducted in a strip-tilled continuous corn field located on a Fort Collins clay loam soil at the Agricultural Research, Development, and Education Center (ARDEC) north of Fort Collins, CO. The plot area had been in a ST-CC production system in 2009. Plots receiving 202 kg N/ha in 2007, 2008, and 2009 were used for this N source study. Fertilizer N sources evaluated were urea (46% N), urea-ammonium nitrate (UAN, 32% N), a polymer-coated urea (ESN, 44% N), a stabilized granular urea (SuperU, 46% N), a stabilized UAN (UAN plus AgrotainPlus), and a slow release N source (UAN + 20% Nfusion, 22% N). All N sources were surface band applied next to the corn row at emergence and watered into the soil with about 19 mm of water with a linear-move sprinkler irrigation system the day after application. An additional ESN treatment was included as a subsurface band application (ESNssb) near the corn row at emergence. A blank treatment (no N applied) was included within the same plot area with the N sources. In addition, a check plot that had not received N for nine years was included in the GHG measurements. The polymer-coated urea, ESN, is produced by Agrium Advanced Technologies, Inc. SuperU is a finished urea product produced by Agrotain International that is a homogenous blend with urease (NBPT) and nitrification (DCD) inhibitors included at the time of production. AgrotainPlus includes these same inhibitors as SuperU and is produced by Agrotain International. The Nfusion added to UAN was a slow release liquid N made up of slowly available urea polymers in the form of methylene urea plus triazone and is produced by Georgia Pacific Chemicals, LLC.

The N treatments were arranged in a randomized complete block design with three replications. Each N source plot was 3 m long x 4.6 m wide. The ST operations were strip-till in March, plant in early May, spray after crop emergence for weed control (twice), and harvest. Grain yield was estimated by harvesting 24 corn plants at maturity, removing the ears, and shelling them to determine grain weight at 15.5% water content. Yields were calculated using established plant stands. Soil samples were collected before spring planting from the 0- to 30.4-cm depth and analyzed for NH_4-N and NO_3-N content.

Greenhouse gas fluxes were generally monitored two to three days per week during the 2010 growing season in each N treatment. Gas samples were collected from two sampling sites within each N treatment replicate for a total of six gas samples for each treatment on each sampling day. A vented chamber technique was used to collect the gases in the field and a gas chromatograph used to analyze gas concentration as described by Mosier et al. (2006). A randomized complete block ANOVA was used to determine differences in N_2O emissions and grain yield among N source treatments.

RESULTS

Greenhouse Gas Emissions. Cumulative N_2O emissions for the growing season are shown in Fig. 1. The N was applied on May 25th (DOY 145) followed by an immediate (within a few days after application) rise in N_2O emissions from urea and UAN. The enhanced efficiency fertilizers (ESN, SuperU, and UAN+AgrotainPlus) had lower N_2O emissions immediately following N application than urea or UAN. This demonstrates the delayed release of NH_4-N from these N sources until later in the growing season. As was the case in 2009 (Halvorson and Del Grosso, 2010a), there was little difference between the check plot that had not received an inorganic N application since 2000 and the blank treatment that had received 202 kg N/ha from 2007-2009.

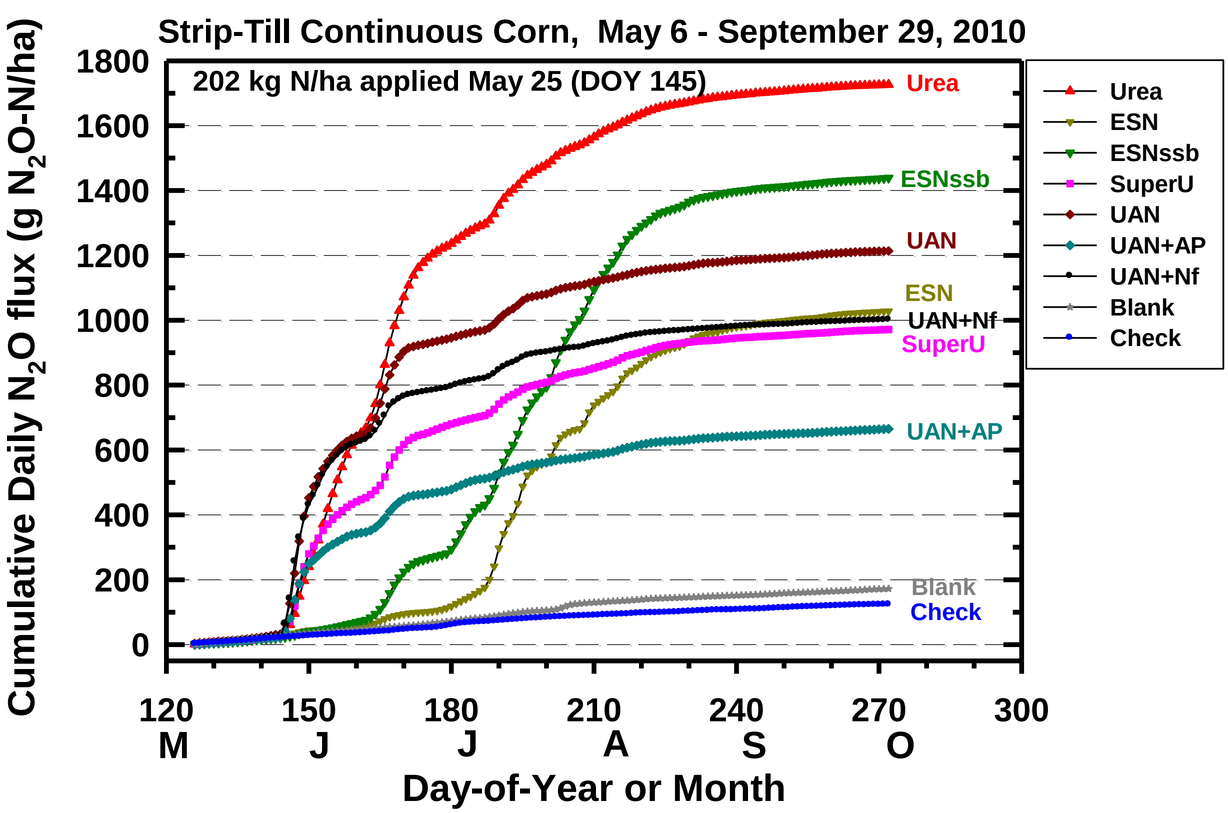

Fig. 1. Cumulative daily N_2O flux during the 2010 growing season for each N treatment.

Differences between N treatments at the end of the growing season are shown in Fig. 2. Dry granular urea had the highest level of N_2O emissions for the growing season and was significantly greater than all other sources except ESNssb (Fig. 2). The higher level of N_2O emission from ESN subsurface banded than ESN surface banded possibly resulted from the soil disturbance during subsurface banding the ESN and a more rapid break down and release of urea from the ESNssb granule which was surrounded by wet soil. Thus a potentially higher concentration of NH_4 in the soil for nitrification with ESNssb than the ESN surface banded. The ESNssb, UAN, ESN, SuperU, and UAN+Nf had similar levels of N_2O emissions for the growing season. Adding AgrotainPlus to UAN resulted in significantly lower N_2O emissions than from UAN. The blank and check treatments were not significantly different. This may indicate increased N_2O emissions occurred only when a new supply of N fertilizer was added. Average spring soil NH_4-N and NO_3-N levels in the 0- to 30.4 cm soil depth were 13 and 26 kg N/ha, respectively, within with the N source plot area. Average spring soil NH_4-N and NO_3-N levels in the 0- to 30.4-cm soil depth were 17and 13 kg N/ha, respectively, in the check plots. Thus, even though there was a slightly higher residual soil N level in the upper 30

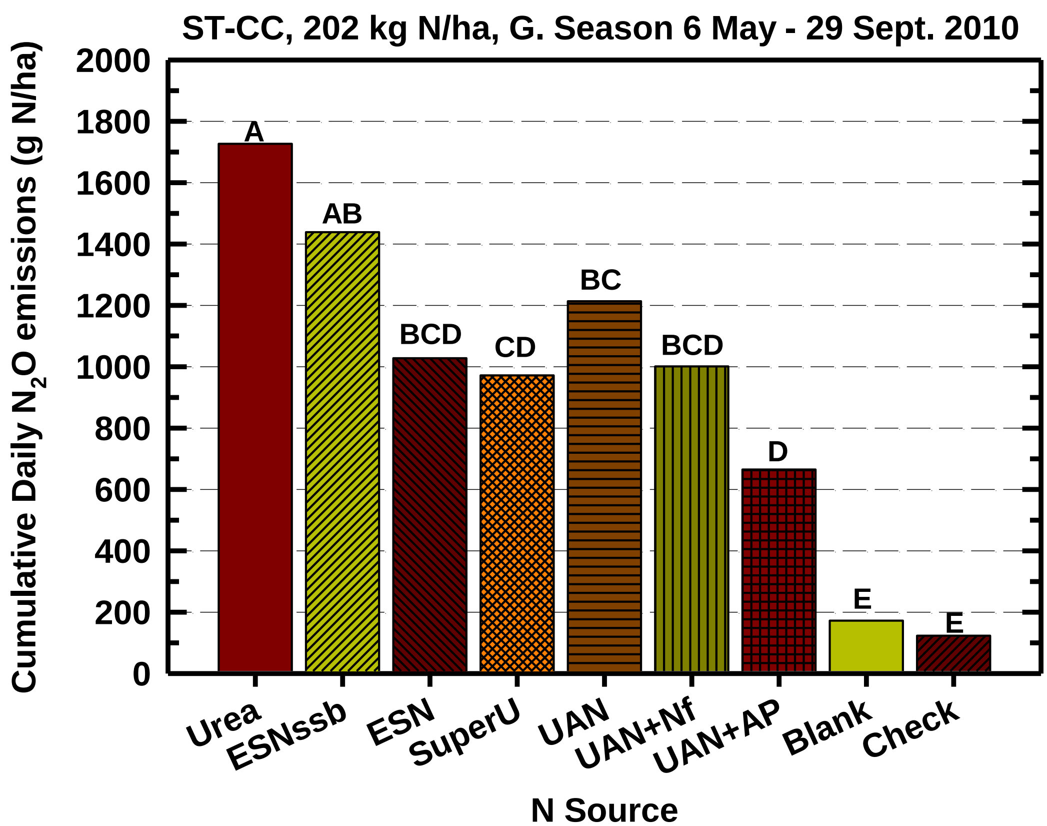

Fig. 2. Cumulative daily N_2O emissions for each N source at end of 2010 growing season. Bars with the same letter on top are not significantly different at $P = 0.05$.

cm of soil in the plots previously receiving fertilizer N than in the check plot, N_2O emissions of the blank treatment were not greater than in the check treatment. The 2010 data confirm the 2009 observation (Halvorson and Del Grosso, 2010a) that there was no difference between the blank and check treatments in N_2O emissions.Grain yields for each of the N treatments are shown in Fig. 3. There was no significant difference in grain yields among the N sources applied, but yields with N application were significantly greater than those of the blank and check treatments. The check treatment receiving no fertilizer N for nine years had significantly lower yields than all other N treatments.

SUMMARY

Growing season N_2O emissions were reduced by all N sources when compared to dry granular urea in this ST continuous corn production system in 2010. Adding AgrotainPlus to UAN significantly reduced growing season N_2O emissions when compared to UAN alone. The 2010 data confirm the 2009 results (Halvorson and Del Grosso, 2010a) that enhanced-efficiency N sources can reduce N_2O emissions from irrigated cropping systems in the semi-arid Central Great Plains.

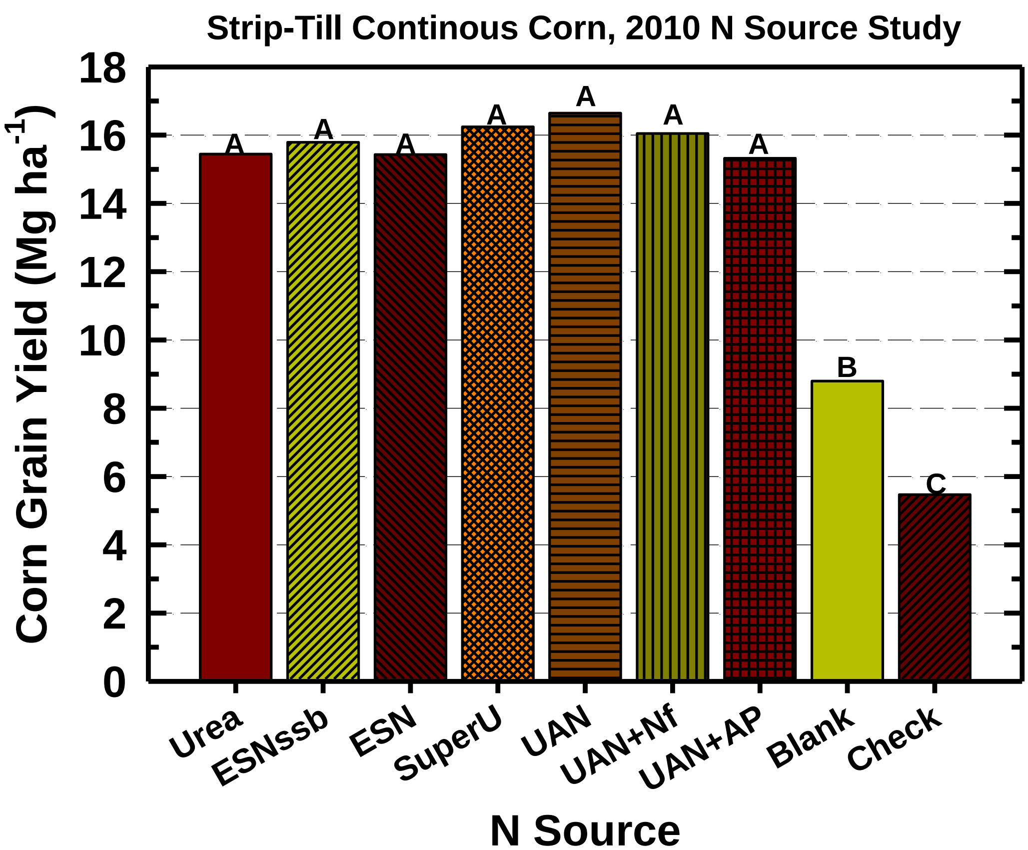

Fig. 3. Grain yields (15.5% water content) for each of the N source treatments in 2010. Bars with the same letter on top are not significantly different at $P = 0.05$.

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