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# NITROUS OXIDE EMISSIONS FROM SEVERAL NITROGEN SOURCES APPLIED TO A STRIP-TILLED CORN FIELD<sup>1</sup>

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## ABSTRACT

We evaluated the effects of nitrogen (N) source on nitrous oxide (N<sub>2</sub>O) 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<sup>1</sup>, 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<sub>2</sub>O emissions than dry granular urea. Cumulative increases in daily N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions (USEPA, 2010). Nitrous oxide has a global warming potential (GWP) approximately 298 times greater than that of CO<sub>2</sub> (Solomon et al., 2007), thus it is important to develop methods that reduce N<sub>2</sub>O emissions in agricultural systems. Nitrogen fertilizer application generally increases N<sub>2</sub>O production from irrigated Central Great Plains cropping systems (Mosier et al., 2006, Halvorson et al., 2008).

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<sup>1</sup>Published in Proceedings of 2011 Fluid Form, Fluid Fertilizer Foundation, February 20-22, 2011, Scottsdale, AZ. Trade names and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the product by the authors or the USDA, Agricultural Research Service.

Available data for analyzing N<sub>2</sub>O emissions impact on GWP in irrigated crop production systems is limited (Mosier et al., 2006; Snyder et al., 2009; Archer and Halvorson, 2010). Research reported by Mosier et al. (2006) and Halvorson et al., (2008, 2010b,c) from irrigated cropping systems exhibited a sharp rise in N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions from corn production systems in Minnesota with greatest N<sub>2</sub>O emissions from anhydrous ammonia application, with significantly lower emissions from UAN, and lowest emissions from broadcast urea. Halvorson et al. (2010b) reported reduced N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions with the polymer-coated urea products.

Our objective was to determine the effects of N fertilizer source on growing season N<sub>2</sub>O 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  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$  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  $\text{N}_2\text{O}$  emissions and grain yield among N source treatments.

## RESULTS

**Greenhouse Gas Emissions.** Cumulative  $\text{N}_2\text{O}$  emissions for the growing season are shown in Fig. 1. The N was applied on May 25<sup>th</sup> (DOY 145) followed by an immediate (within a few days after application) rise in  $\text{N}_2\text{O}$  emissions from urea and UAN. The enhanced efficiency fertilizers (ESN, SuperU, and UAN+AgrotainPlus) had lower  $\text{N}_2\text{O}$  emissions immediately following N application than urea or UAN. This demonstrates the delayed release of  $\text{NH}_4\text{-N}$  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.

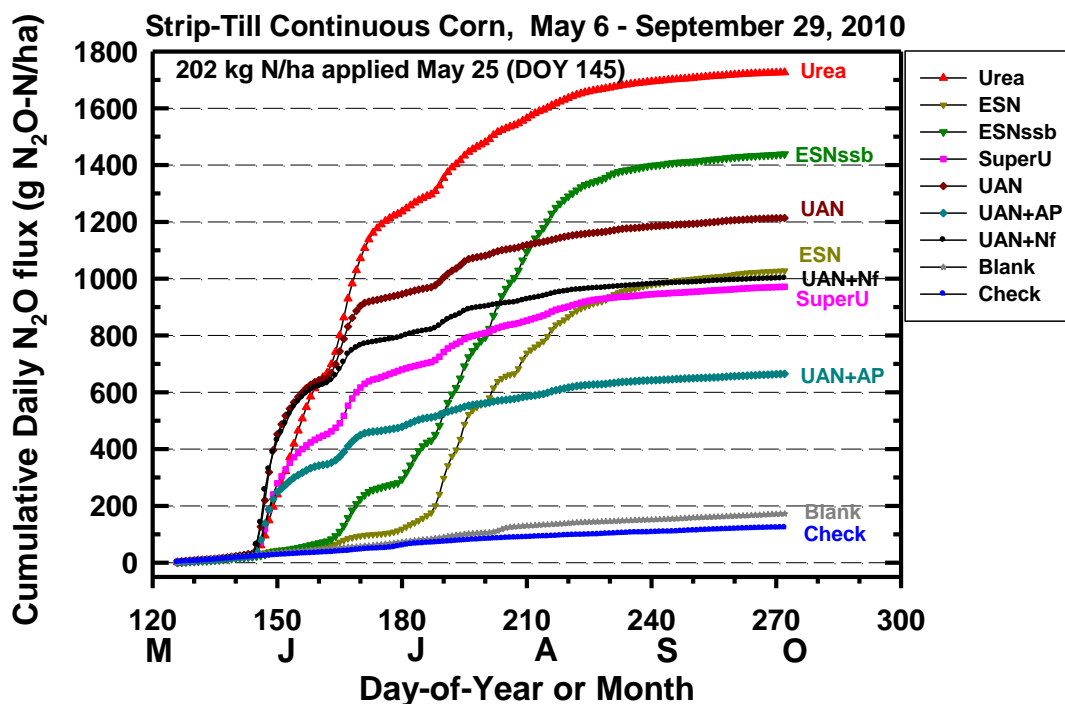


Fig. 1. Cumulative daily  $\text{N}_2\text{O}$  flux during the 2010 growing season for each N treatment.

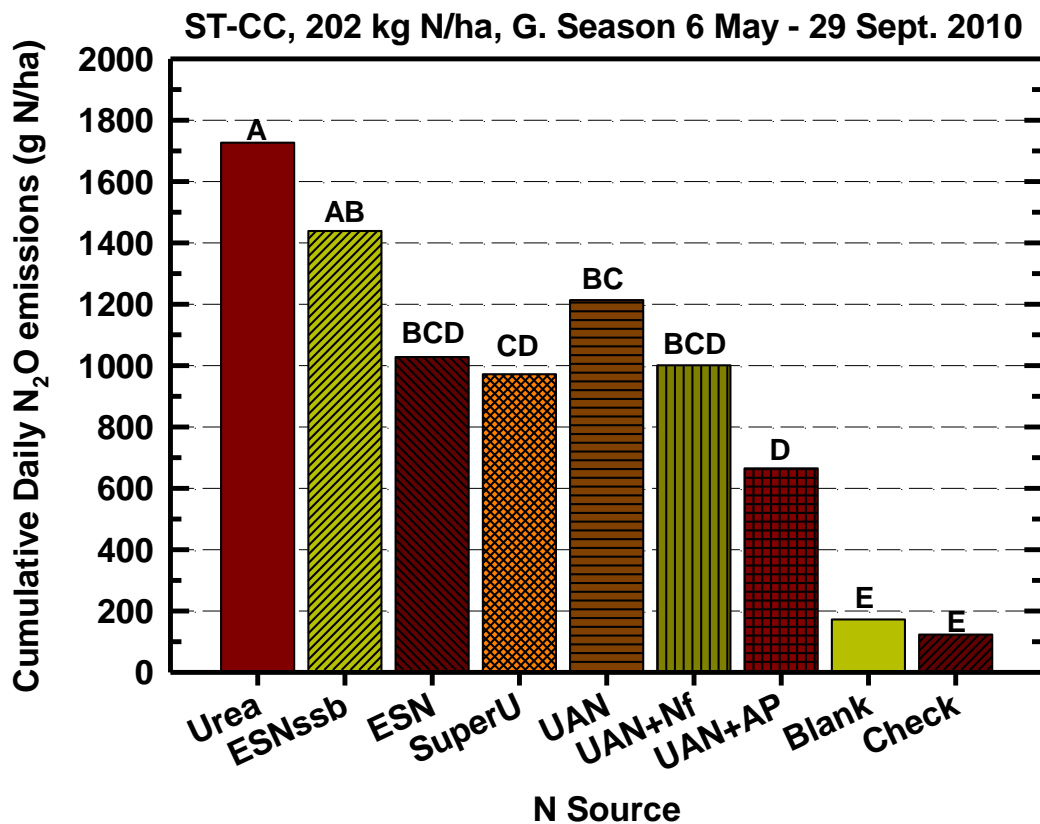


Fig. 2. Cumulative daily N<sub>2</sub>O emissions for each N source at end of 2010 growing season. Bars with the same letter on top are not significantly different at  $P = 0.05$ .

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<sub>2</sub>O emissions for the growing season and was significantly greater than all other sources except ESNssb (Fig. 2). The higher level of N<sub>2</sub>O 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<sub>4</sub> 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<sub>2</sub>O emissions for the growing season. Adding AgrotainPlus to UAN resulted in significantly lower N<sub>2</sub>O emissions than from UAN. The blank and check treatments were not significantly different. This may indicate increased N<sub>2</sub>O emissions occurred only when a new supply of N fertilizer was added. Average spring soil NH<sub>4</sub>-N and NO<sub>3</sub>-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<sub>4</sub>-N and NO<sub>3</sub>-N levels in the 0- to 30.4-cm soil depth were 17 and 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 cm of soil in the plots previously receiving fertilizer N than in the check plot, N<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O 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<sub>2</sub>O emissions from irrigated cropping systems in the semi-arid Central Great Plains.

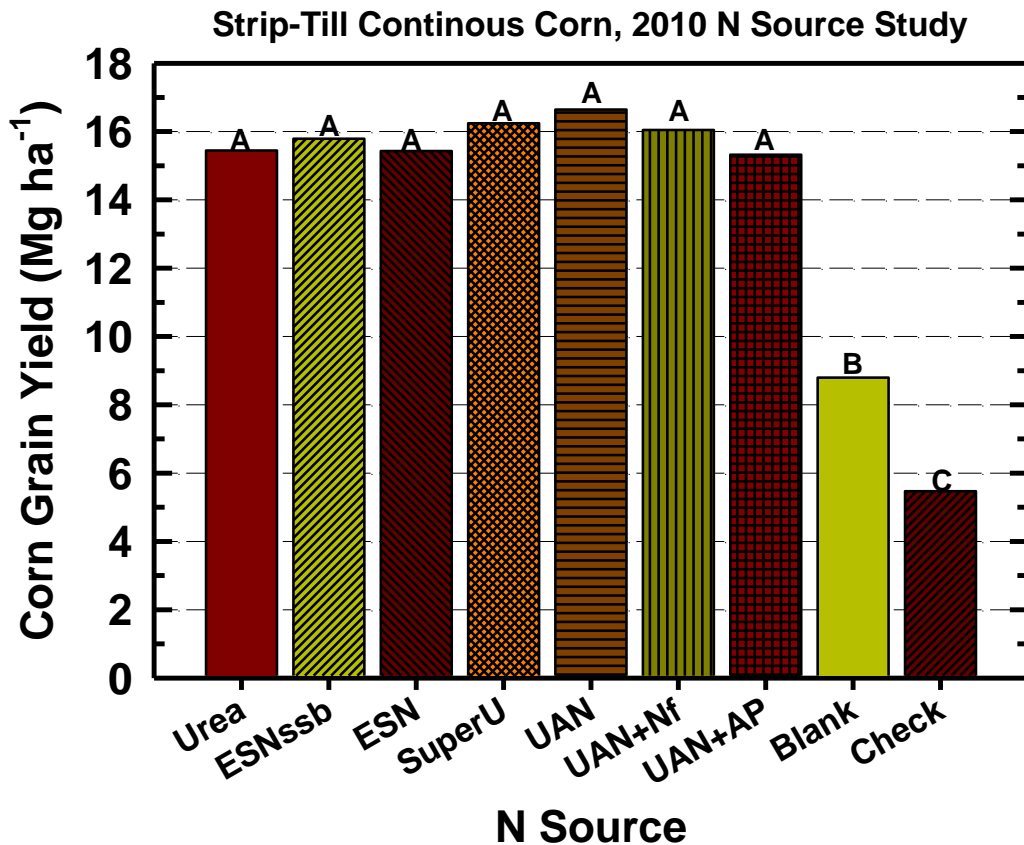


Fig. 3. Grain yields (15.5% water content) for each of the N source treatments in 2010. Bars with the same letter on top are not significantly different at  $P = 0.05$ .

## REFERENCES

- Archer, David W., and Ardell D. Halvorson. 2010. Greenhouse gas mitigation economics for irrigated cropping systems in northeastern Colorado. *Soil Sci. Soc. Am. J.* 74(2):446-452.
- Follett, R.F. 2001. Nitrogen transformation and transport processes. p. 17-44. R.F. Follett and J.L. Hatfield (eds.), *Nitrogen in the Environment: Sources, Problems, and Management*. Elsevier Science B.V., Amsterdam, The Netherlands.
- Halvorson, Ardell D., and Stephen J. Del Grosso. 2010a. Nitrogen source affects nitrous oxide emissions in a strip-tilled continuous corn field. p. 30-36. *In* A.J. Schlegel and H.D. Bond (Eds.), *Great Plains Soil Fertility Conf. Proc.* Vol. 13. Denver, CO. 2-3 March 2010 Kansas State University, Manhattan and Potash and Phosphate Institute, Brookings, SD.
- Halvorson, A.D., S.J. Del Grosso, and C.A. Reule. 2008. Nitrogen, tillage, and crop rotation effects on nitrous oxide emissions from irrigated cropping systems. *J. Environ. Qual.* 37:1337-1344.
- Halvorson, Ardell D., Stephen J. Del Grosso, and Francesco Alluvione. 2010b. Tillage and inorganic nitrogen source effects on nitrous oxide emissions from irrigated cropping systems. *Soil Sci. Soc. Am. J.* 74(2):436-445.
- Halvorson, Ardell D., Stephen J. Del Grosso, and Francesco Alluvione. 2010c. Nitrogen source effects on nitrous oxide emissions from irrigated no-till corn. *J. Environ. Qual.* 39:1554-1562.
- Hyatt, C.R., R.T. Venterea, C.J. Rosen, M. McNearney, M.L. Wilson, and M.S. Dolan. 2010. Polymer-coated urea maintains potato yields and reduces nitrous oxide emissions in a Minnesota loamy sand. *Soil Sci. Soc. Amer. J.* 74:419-428.
- Mosier, A.R., A.D. Halvorson, C.A. Reule, and X.J. Liu. 2006. Net global warming potential and greenhouse gas intensity in irrigated cropping systems in northeastern Colorado. *J. Environ. Qual.* 35:1584-1598.
- Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood and D. Wratt. 2007. Technical Summary. *In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 74p.
- Snyder, C.S., T.W. Bruulsema, T. L. Jensen, and P. E. Fixen. 2009. Review of greenhouse gas emissions from crop production systems and fertilizer management effects. *Agric. Ecosyst. Environ.* 133:247-266.
- USEPA. 2010. Inventory of U.S. greenhouse gas emissions and sinks: 1990-2008. U.S. Environmental Protection Agency, 1200 Pennsylvania Ave., N.W. Washington, DC 20460. EPA 430-R-10-006. <http://epa.gov/climatechange/emissions/usinventoryreport.html>
- Venterea, R.T., M. Burger, and K.A. Spokas. 2005. Nitrogen oxide and methane emissions under varying tillage and fertilizer management. *J. Environ. Qual.* 34:1467-1477.



Venterea, R.T., M.S. Dolan, and T.E. Ochsner. 2010. Urea decreases nitrous oxide emissions compared with anhydrous ammonia in a Minnesota corn cropping system. *Soil Sci. Soc. Amer. J.* 74:407-418.

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