International Conference on Enhanced-Efficiency Fertilizers

An IFA-New Ag International Event
23-24 March 2010
Hotel Hyatt Regency, Miami, FL, USA

THE EFFECT OF ENHANCED-EFFICIENCY FERTILIZERS ON NITROUS OXIDE EMISSIONS FROM VARIOUS CROPPING SYSTEMS

Ardell D. HALVORSON
USDA-ARS, USA

International Fertilizer Industry Association

NEW AG INTERNATIONAL

The Effect of Enhanced-Efficiency Fertilizers on Nitrous Oxide Emissions from Various Cropping Systems

Ardell D. Halvorson and Stephen J. Del Grosso
USDA-ARS, Fort Collins, CO; email: ardell.halvorson@ars.usda.gov
Rod Venterea, USDA-ARS, **and Carl Rosen,** Univ. MN, St. Paul, MN
Jeff Smith, USDA-ARS, Pullman, WA
Tim Parkin and Jerry Hatfield, USDA-ARS, Ames, IA
Karamat Sistani, USDA-ARS, Bowling Green, KY
Curtis Dell, USDA-ARS, University Park, PA
Dexter Watts, USDA-ARS, Auburn, AL

Presented at International Conference on Enhanced-Efficiency Fertilizers, Miami, Florida, USA
March 23-24, 2010

ARS Soil-Plant-Nutrient Research Unit

Background Information:

- Agriculture contributes ~67% of U.S. total N_2O emissions.
- Global Warming Potential of N_2O is ~296 times greater than CO_2.
- Applying N fertilizer generally increases N_2O emissions.
- Developing management practices to reduce N_2O emissions in agricultural systems is important.
- USDA-ARS is evaluating the effects of N source on N_2O emissions at 7 locations with differing climates, soils, and cropping systems.

Objective of N Source Studies:

- Compare N_2O emissions resulting from application of several N sources to different cropping systems under varying soil and climatic conditions.
- N Sources Evaluated:
  - Conventional N fertilizers: Urea and/or UAN
  - Stabilized N sources containing urease (NBPT) and nitrification (DCD) inhibitors: SuperU and/or UAN+AgrotainPlus (AP).
  - Polymer-coated ureas: ESN, Duration III, Kingenta
  - Other Sources Examined: UAN + Nfusion; PiNT (Plant Impact N Technology); Ammonium Nitrate; Ammonium Sulfate; Urea-Ammonium Sulfate.

Research Details

Presented Separately for Each Site:

Soil Texture

Growing Season Precipitation

Irrigation Amount

Cropping and Tillage Systems

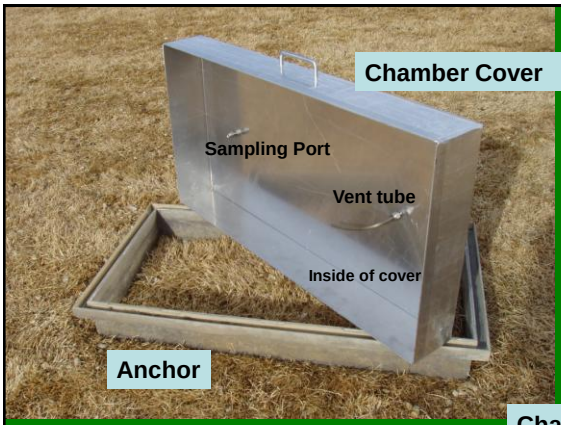
N Fertilization Rate

Fertilizer Application method

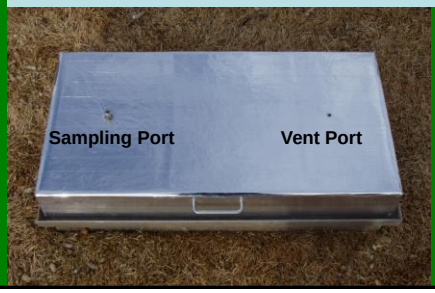
Band applying SuperU at corn emergence in NT-CDb rotation in 2008 at Fort Collins, CO.

Greenhouse Gas Measurements

- Randomized complete block designs with 3 or 4 replications were generally used.
- N_2O measurements: 1 to 3 times per week, immediately following crop planting until crop harvest (growing season).
- Static, vented chamber technique used to collect the gas samples in the field.
- Gas chromatograph used to determine N_2O concentration in field gas samples.



Chambers used at Fort Collins



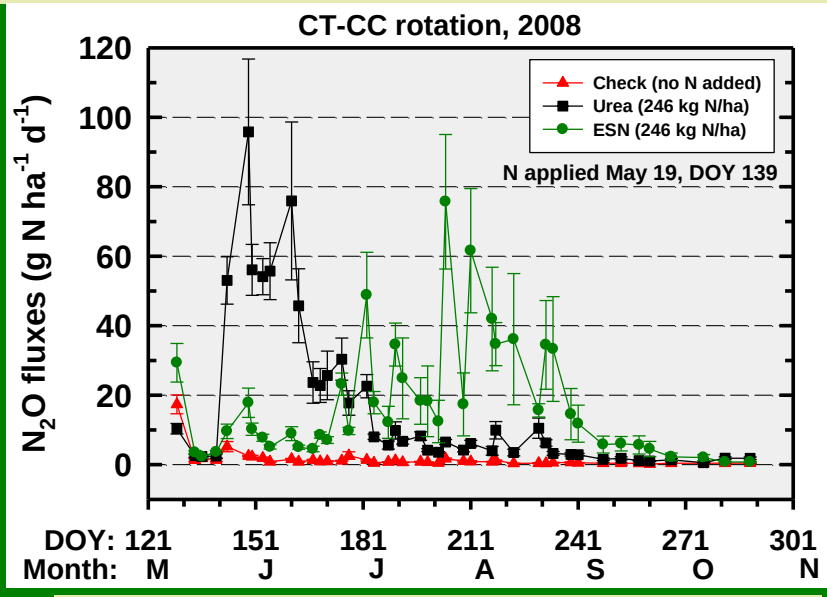
Chamber Cover installed on Anchor

A. Halvorson, USDA-ARS, Fort Collins, CO

ARS Technicians collecting GHG samples, soil temp, and water data in ST-CC rotation

Injecting field gas samples into vials for analysis on Varian 3800 GC.

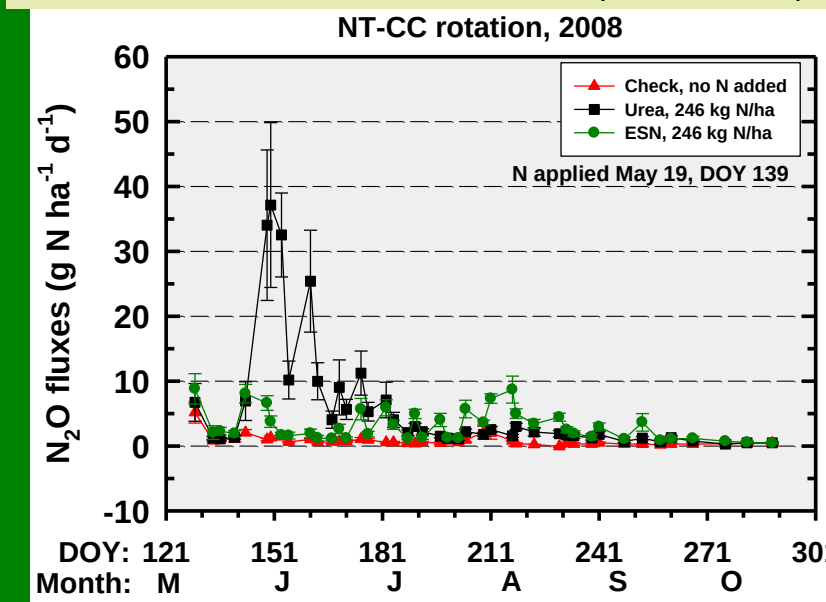
Urea vs ESN in Conventional Till Corn, Fort Collins, CO



Clay loam soil; GS precip. =241mm; irrigation = 360mm; N band applied

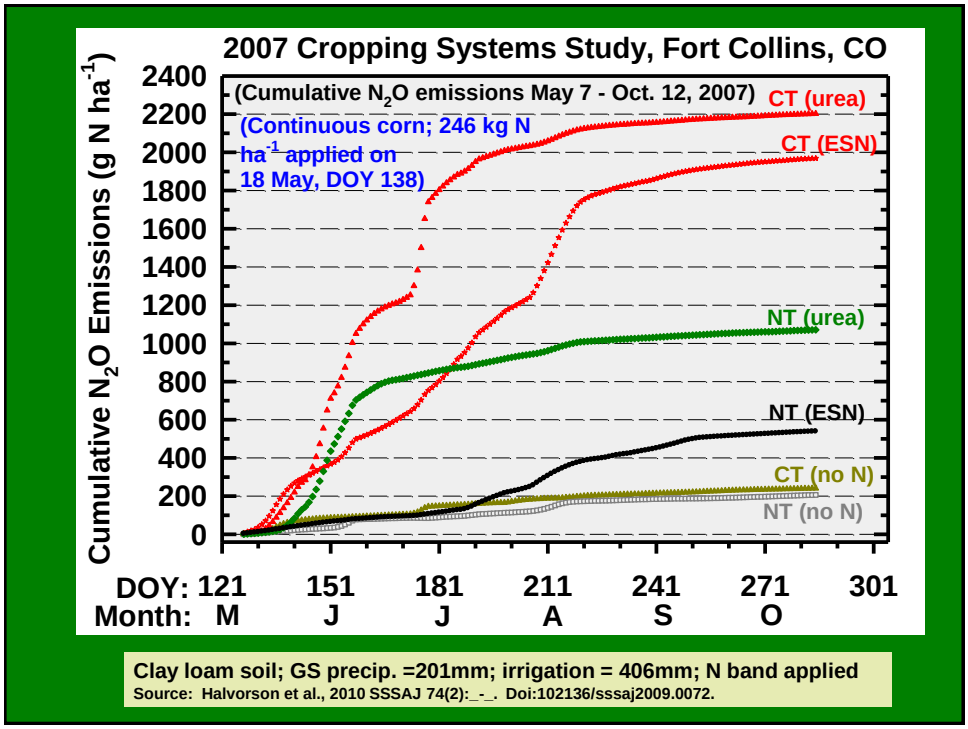
Source: Halvorson et al., 2010 SSSAJ 74(2):_-_. Doi:102136/sssaj2009.0072.

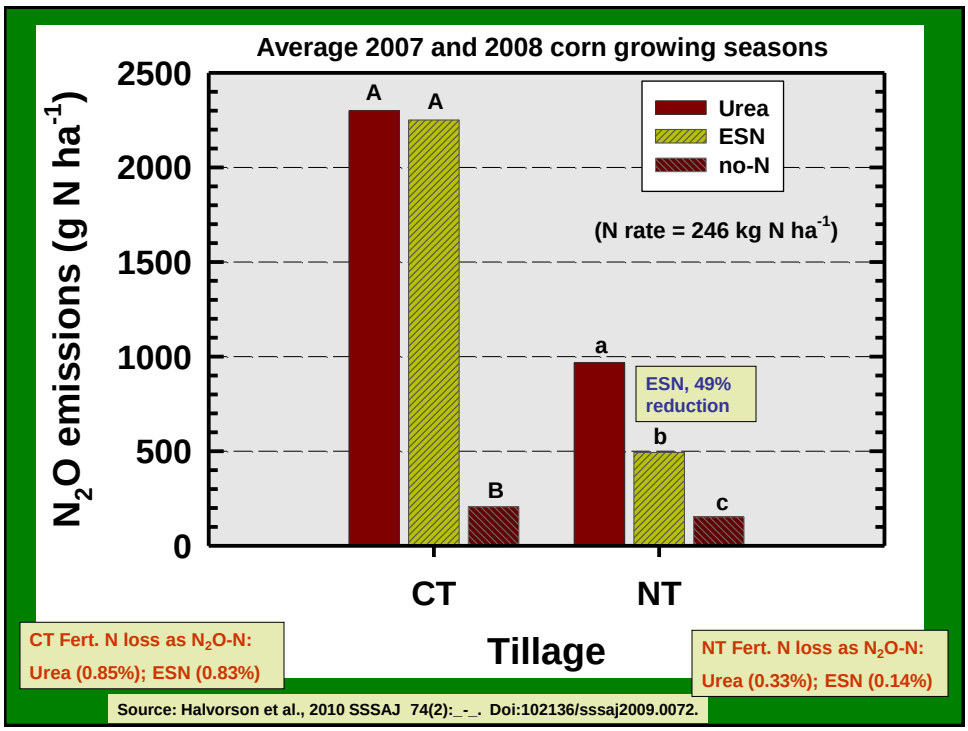
Urea vs ESN in no-till continuous corn, Fort Collins, CO



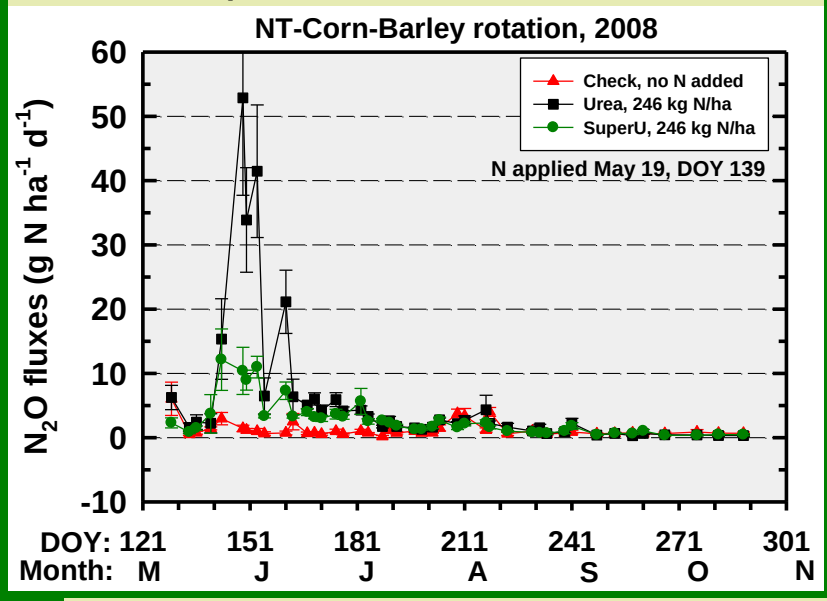
Clay loam soil; GS precip. =241mm; irrigation = 360mm; N band applied

Source: Halvorson et al., 2010 SSSAJ 74(2):_-_. Doi:102136/sssaj2009.0072.


2007 Cropping Systems Study, Fort Collins, CO
(Cumulative N_2O emissions May 7 - Oct. 12, 2007)
(Continuous corn; 246 kg N ha^{-1} applied on 18 May, DOY 138)
CT (urea)
CT (ESN)
NT (urea)
NT (ESN)
CT (no N)
NT (no N)
Cumulative N_2O Emissions (g N ha^{-1})
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
DOY: 121 151 181 211 241 271 301
Month: M J J A S O
Clay loam soil; GS precip. =201mm; irrigation = 406mm; N band applied
Source: Halvorson et al., 2010 SSSAJ 74(2):_-_. Doi:102136/sssaj2009.0072.

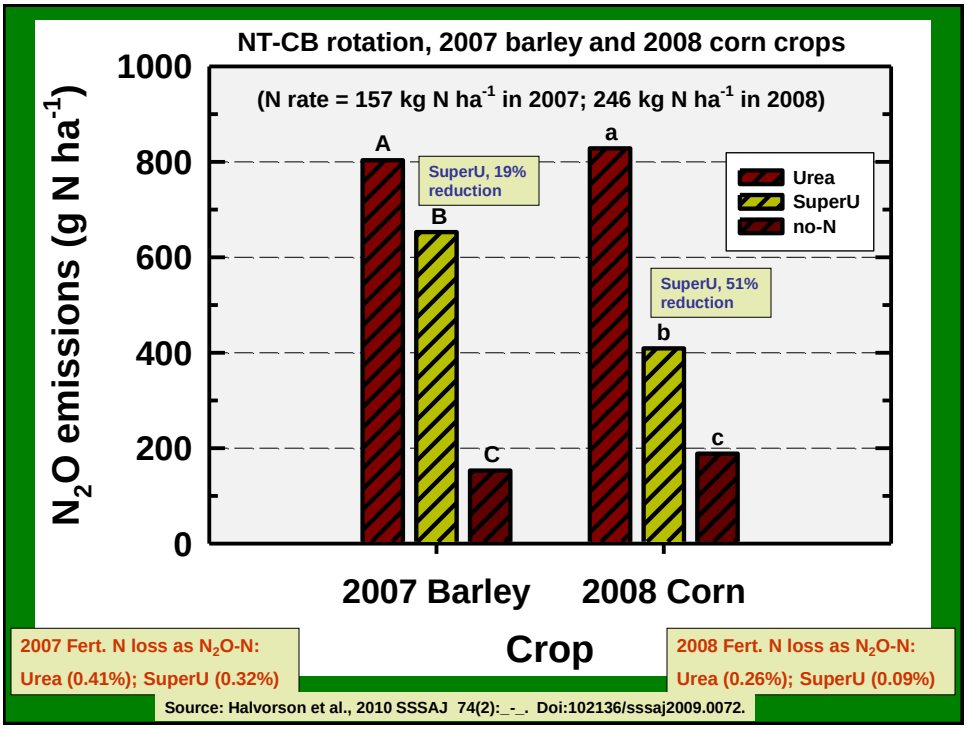

Average 2007 and 2008 corn growing seasons
N_2O emissions (g N ha^{-1})
2500
2000
1500
1000
500
0
A
A
B
a
b
c
Urea
ESN
no-N
(N rate = 246 kg N ha^{-1})
ESN, 49% reduction
CT
NT
Tillage
CT Fert. N loss as N_2O-N:
Urea (0.85%); ESN (0.83%)
NT Fert. N loss as N_2O-N:
Urea (0.33%); ESN (0.14%)
Source: Halvorson et al., 2010 SSSAJ 74(2):_-_. Doi:102136/sssaj2009.0072.

Urea vs SuperU in no-till corn, Fort Collins, CO



Clay loam soil; GS precip. =241mm; irrigation = 360mm; N band applied

Source: Halvorson et al., 2010 SSSAJ 74(2):_-_. Doi:102136/sssaj2009.0072.



2007 Fert. N loss as N_2O-N: Urea (0.41%); SuperU (0.32%)

2008 Fert. N loss as N_2O-N: Urea (0.26%); SuperU (0.09%)

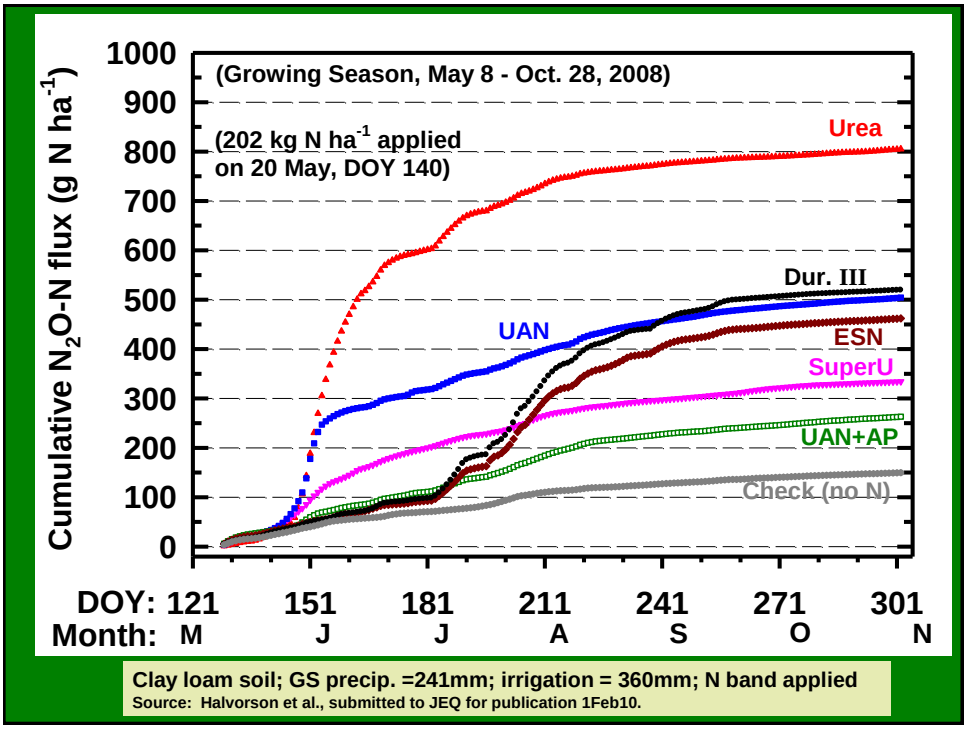
Source: Halvorson et al., 2010 SSSAJ 74(2):_-_. Doi:102136/sssaj2009.0072.

N Source Study at Fort Collins, CO under NT continuous corn

- **N Rates:**
  - 0 and 246 kg N/ha (2007);
  - 0 and 202 kg N/ha (2008)
- **N Sources Evaluated: (all sources surface banded at crop emergence, followed by 13 mm irrigation water within 2 days)**
  - Dry granular **Urea**
  - Polymer-Coated Urea (**ESN** and **Duration III**)
  - **SuperU** (contains urease and nitrification inhibitors)
  - **UAN**
  - **UAN + AgrotainPlus** (contains urease and nitrification inhibitors)

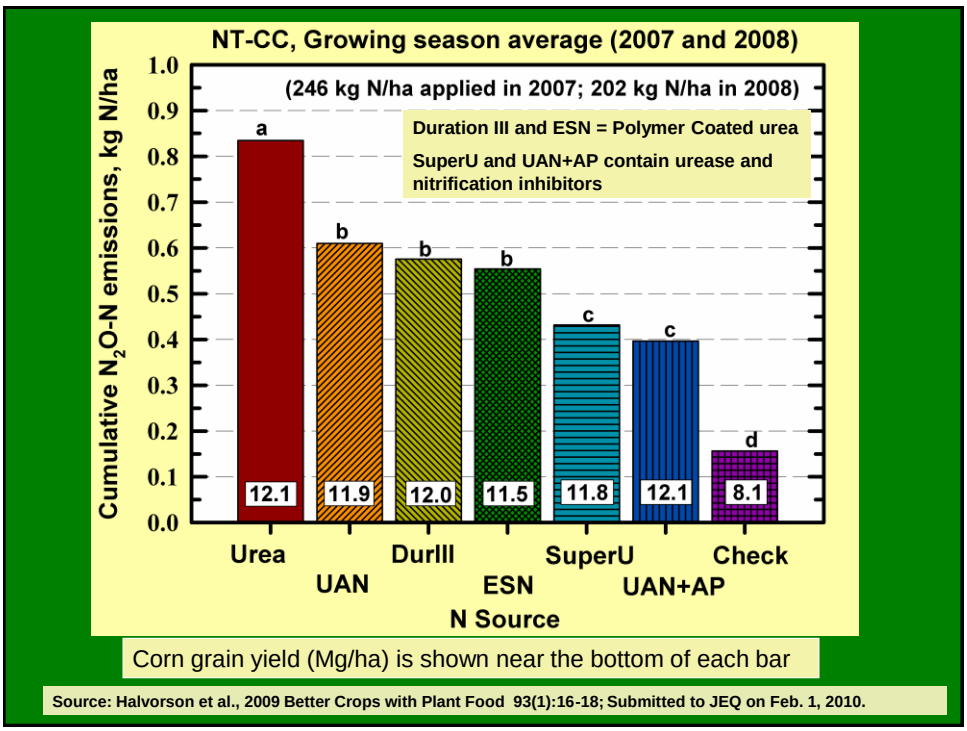
Source: Halvorson et al., 2009 Better Crops with Plant Food 93(1):16-18; Submitted to JEQ on Feb. 1, 2010.

Applying dry and liquid N sources to plots in N source Study (2008)



Clay loam soil; GS precip. =241mm; irrigation = 360mm; N band applied

Source: Halvorson et al., submitted to JEQ for publication 1Feb10.



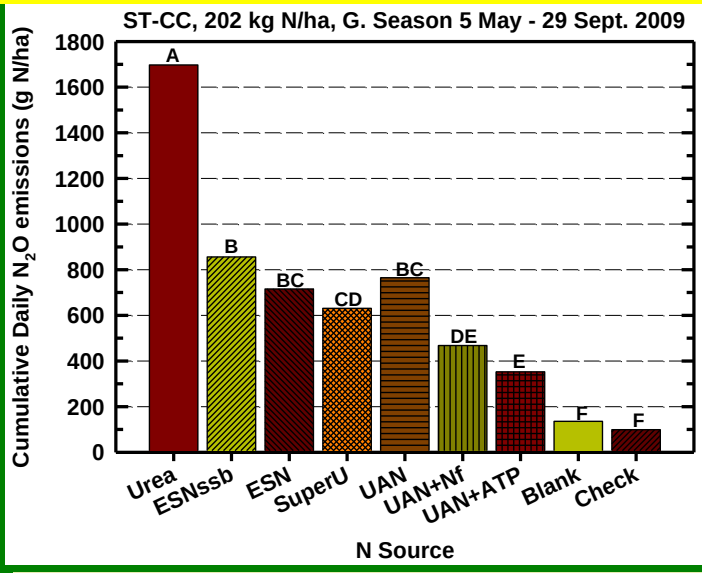
Corn grain yield (Mg/ha) is shown near the bottom of each bar

Source: Halvorson et al., 2009 Better Crops with Plant Food 93(1):16-18; Submitted to JEQ on Feb. 1, 2010.

N Source Effects on Reducing N_2O-N Emissions in NT-CC

- **Compared to Urea**
  - UAN (27%)
  - Duration III (31%)
  - ESN (34%)
  - SuperU (48%)
  - UAN + AgrotainPlus (53%)
- **Compared to UAN**
  - Duration III (6%)
  - ESN (9%)
  - SuperU (29%)
  - UAN + AgrotainPlus (35%)

2009 N_2O-N Emissions from Several N sources applied to Strip-Till Corn, Fort Collins, CO



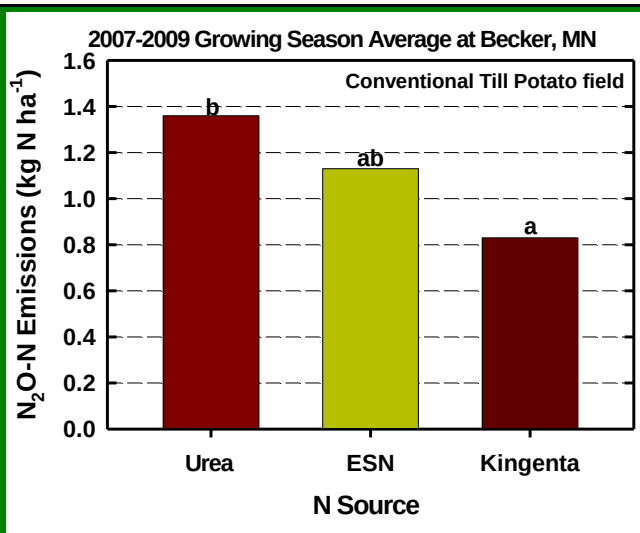
N_2O-N loss per unit of N applied was:
0.8% Urea
0.4% ESNssb
0.3% ESN
0.3% SuperU
0.3% UAN
0.2% UAN+Nf
0.1% UAN+AP

Clay loam soil; GS precip. =259mm; irrigation = 397mm; N banded at corn emergence.
Source: Halvorson and Del Grosso, Proc. 2010 Great Plains Soil Fertility Conference, March 2-3, Denver, CO

N Source vs N_2O-N Emissions

Results from

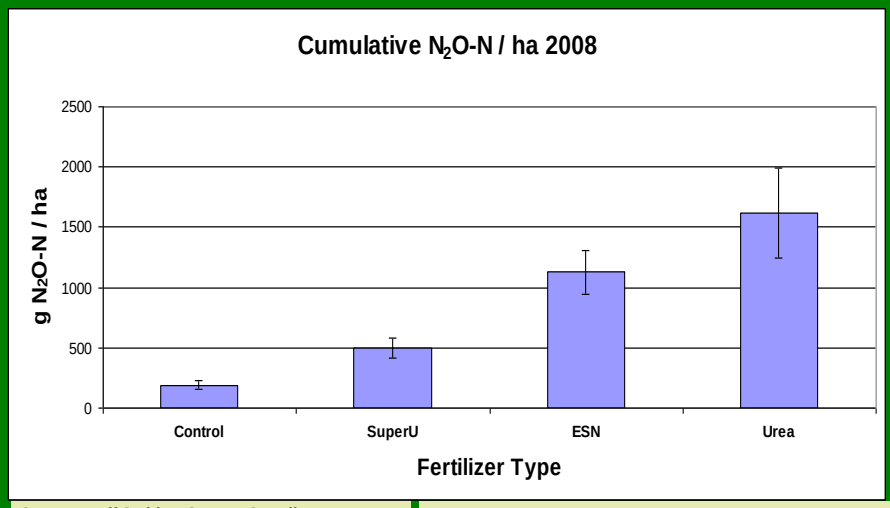
Other USDA-ARS Locations



Source: Hyatt et al. 2010 SSSAJ 74(2)_-_. Doi:10.2136/sssaj2009.0126.

N_2O-N loss as a percent of the N applied ranged from 0.1% to 0.5% in this study

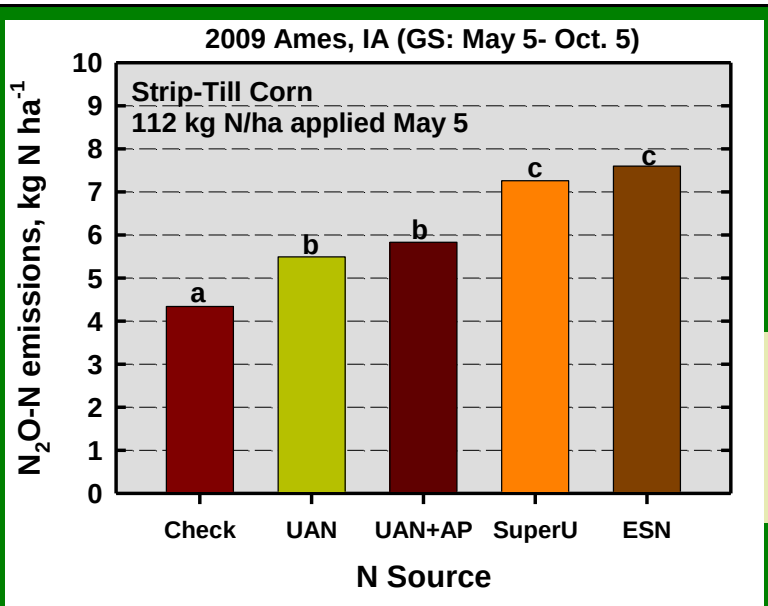
Loamy sand soil; 3yr average GS precip. =394mm and irrigation = 423mm; N rates: ESN and Kingenta were applied at 225 kg N/ha preplant; Urea was applied 112 kg N/ha at emergence and 5 post-emergence applications of 22.5 kg N/ha in 2007 and 4 post-emergence applications of 28 kg N/ha in 2008 and 2009; N broadcast incorporated.



Source: Jeff Smith, USDA-ARS, Pullman, WA

N_2O-N loss per unit of N applied was about 1.1% for Urea, 0.8% for ESN, 0.2% for SuperU

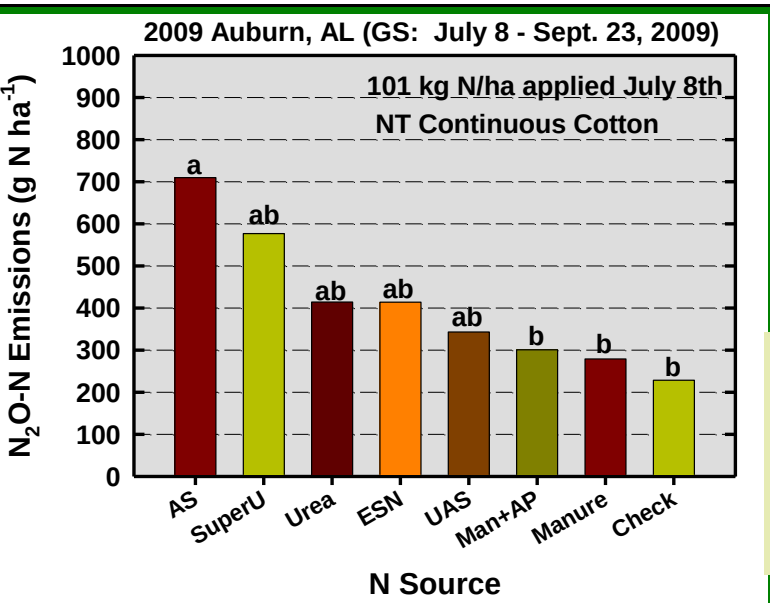
Silt loam soil; GS precip. =135mm; irrigation = none;
N rate = 123 kg N/ha; N surface broadcast applied on Oct. 27, 2007;
cropping system = no-till winter wheat.



Source: Tim Parkin and Jerry Hatfield, USDA-ARS, Ames, IA

N_2O-N loss per unit of N applied was:
1.0% UAN
1.3% UAN+AP,
2.6% SuperU
2.9% ESN

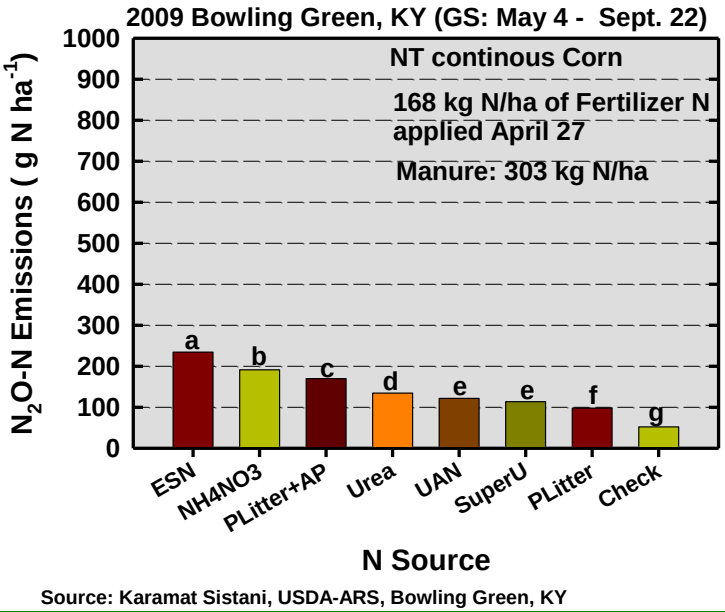
Silty clay loam and Clay loam soils; GS precip. =700mm; irrigation = none; N surface broadcast applied; crop rotation = corn on corn.



Source: Dexter Watts, Allen Torbert, Katy Smith, USDA-ARS, Auburn, AL

N_2O-N loss per unit of N applied was:
0.5% AS
0.3% SuperU
0.2% Urea
0.2% ESN
0.1% UAS
<0.1% Manure

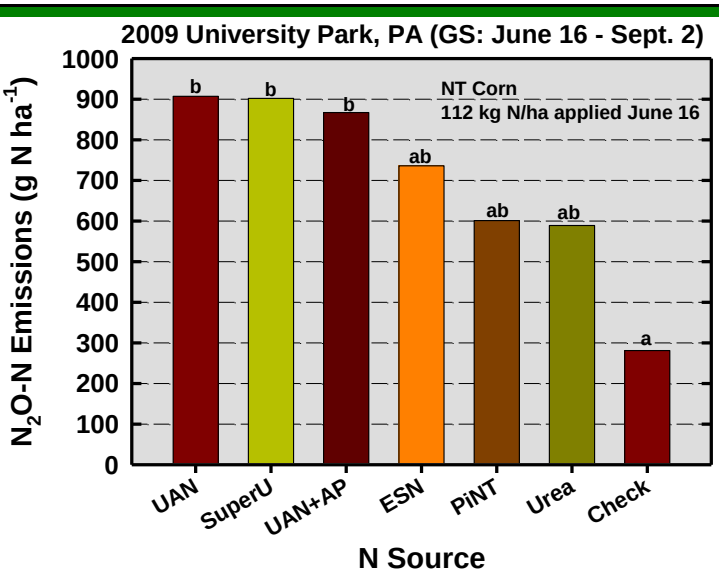
Loamy sand soil; GS precip. =831mm; irrigation = 36mm; N surface broadcast applied; crop rotation = no-till continuous cotton.



Source: Karamat Sistani, USDA-ARS, Bowling Green, KY

N_2O-N loss per unit of N applied was:
0.1% ESN
<0.1% NH_4NO_3
<0.1% PL+AP
<0.1% Urea
<0.1% UAN
<0.1% SuperU
<0.1% PLitter

Silt loam soil; GS precip. =792mm; irrigation = none; N surface broadcast applied; no-till continuous corn.



N_2O-N loss per unit of N applied was:
0.6% UAN
0.6% SuperU
0.5% UAN+AP
0.4% ESN
0.3% PiNT
0.3% Urea

Source: Curtis Dell, John Schmidt, and Ray Bryant, USDA-ARS, Univeristy Park, PA

Well drained silt loam soil; GS precip. =640mm; irrigation = none; granular N surface broadcast applied, liquids surface band applied; no-till corn rotation.

Summary

- Enhanced-efficiency N sources ESN, SuperU, and UAN+ AgrotainPlus reduced N_2O emissions up to 50% in NT production systems in the semi-arid western U.S. when compared to urea.
- ESN was not effective in reducing N_2O-N loss in CT-CC but reduced N_2O emissions 49% in NT-CC at Fort Collins.
- In the more humid areas (central, eastern and southern U.S.), the effectiveness of enhanced-efficiency N sources in reducing N_2O-N emissions is not as obvious and needs more study.
- Growing season N_2O-N losses per unit of N applied were generally well below the 1% loss value used by IPCC and generally <0.6% at most locations except for Ames, IA where N_2O-N losses per unit of N applied were >1%.

Thanks to Funding Sources

- USDA-ARS
- USDA-ARS GRACEnet program
- Foundation for Agronomic Research (FAR) with funding from Agrium, Inc. and Agrotain International
- Agrium Advanced Technologies
- Georgia Pacific Chemicals, LLC
- Shandong Kingenta Ecological Eng. Co. Ltd.